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From a photograph taken at the Yerkes Observatory

Field Book of The Skies

A Presentation of the Main Facts of Modern Astronomy and a Practical Field Book for the Observer

By

William Tyler Olcott

Author of "Star Lore of All Ages," "Sun Lore of All Ages," "Book of Stars for Young People," etc.

and

Edmund W. Putnam

Author of "The Essence of Astronomy," etc.

Illustrated from Photographs and with many Diagrams and Charts

G. P. Putnam's Sons
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The Knickerbocker Press
1929

FIELD BOOK OF THE SKIES

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by
William Tyler Olcott

First Edition

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The University of Texas
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The Knickerbocker Press
New York

Made in the United States of America

To

CLARA H. OLCOTT

WHO HAS INSPIRED, ENCOURAGED, AND ASSISTED THESE EFFORTS TO FOSTER AND PROMOTE AN INTEREST IN THE STARS

"For ye are
A beauty and a mystery, and create
In us such love and reverence from afar
That fortune, fame, power, life have
Named themselves a star."

—Byron

PREFACE

The purpose of this book is fivefold:

To present to those who know nothing about Astronomy an easily comprehended epitome of present-day astronomical knowledge, avoiding as far as possible technicalities and mathematical statistics;

To give a brief outline of the Mythology of the Heavens;

To teach the beginner how to identify the constellations and the individual stars;

To offer to the more experienced observer a practical field book conveniently arranged with a double system of charts with accompanying texts—one for naked eye and field glass work, the other for the small telescope;

And last, but certainly not least, to stimulate, not only a general interest in astronomy, but a special observational work.

Many readers of this book may be the fortunate owners of small telescopes. (It may be well to point out that a good three-inch glass is *not* an expensive luxury.) Perhaps they have observed the heavens from time to time in a desultory way, and have grown rather tired of celestial sight-seeing, so that their instruments are left in idleness. It is not probable that these owners know that there is practical scien-

tific work that they can do—work that involves no *obligation* in either money or time, that is ceaselessly fascinating, and that is of very real value. If those who are willing to co-operate in the great work of astrophysical research will communicate with William Tyler Olcott, 62 Church Street, Norwich, Conn., he will be pleased to outline for them this observational work, which is easy to do, and which will enable them to share in the advance of our knowledge of the stars.

To sum up, then, the aim of this book is to furnish the reader with a good *general,* knowledge of astronomy, with the hope that it will lead him to a deeper study, or, at least, induce him to undertake observational work which is of scientific value, is intellectually profitable, and is a source of continued enjoyment.

If the book succeeds in any of these aims, the writers will be amply repaid for their endeavor to make the first steps in the study of Astronomy lucid and interesting.

W. T. O.
E. W. P.

Norwich, Conn.,
July, 1929.

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FIELD BOOK OF THE SKIES

WHY STUDY ASTRONOMY?

"Why should I study astronomy? What use is it to me?"

These two questions are, unfortunately, asked so often that it seems fitting to begin this book with answers to both.

Taking them in reverse order, the reply to the second question is: It is of no use! It is of no more *use* than a knowledge of music, a friendship with the birds and flowers, or a conversance with real literature or art. It surely may be doubted that the ability to call a wild-flower by its correct name; to recognize a Beethoven theme, a harmony of Brahms, or a Schubert melody; or the knowledge that La Gioconda was painted by Leonardo da Vinci, and that by far the most admirable character created by Milton was the devil himself, has ever turned an honest penny for, or proved of practical use to, that much cited individual—the average man. The value of such knowledge is, of course, another matter; but, if you are looking for *use*, put down this book and turn back to your study of market, business and social problems.

The first question may be answered even more briefly: Don't! unless you enjoy it. Without a special bent, study is trying work, and our friend the average man has, these days, enough work

that must be done without adding to it unnecessarily. And, for his astronomical needs, study is not required. How many enthusiastic happy and successful amateur flower gardeners have studied botany; and how many of the rapt listeners, millions since the advent of the radio, who every Sunday steep themselves in floods of symphonic harmony, have ever attempted to master the mathematics of that harmony? Do they lack an understanding enjoyment of either the flowers or the music? Quite the contrary, they may even hold an advantage over the *student* who is prone to be betrayed by technicalities, which are treacherous and terrible things, into tearing ruthlessly from its shrine the true sense of beauty and rearing in its place a false idol. Too often, he sees not the flower, but the way it is grown; he hears not the music, only the way it is composed. The myopic worshipper of the technical cannot see the forest for the trees; he is so absorbed in method and detail that he is indifferent to the distortion of the whole. It is he who is responsible for the Picasso's and the Stravinski's of both art and science.

It is a sad truth that there are astronomers, so called, with such narrow vision that figures and facts are all they can see of the heavens; to whom a night under the stars is unknown, and to whom a theory is anathema. They write books—text-books, accurate text-books, dry-as-dust text-books—and with their horrid array of calculations and statistics terrify people into the misbelief that astronomy is merely for the mathematician. These books are necessary for their pur-

pose, but leave them alone, dear general reader, for they have as little to do with the enjoyment of astronomy as has botanical dissection to do with the appreciation of the beauty of a rose, or the logarithms of the diapason with an understanding of music.

The foregoing paragraph may read bitterly—it was intended to. For years, the writer, a Nature lover, has contended with this mathematical Hydra that frightens other lovers of Nature from the path to one of her most glorious fields—and has contended with little success.

"But," you ask, "why should I bother my head about astronomy at all?" There are many good reasons; two should suffice: education and recreation.

Without discussing the fact that knowledge for itself alone is worth while, it must be stressed at once that no one can rightly consider himself educated without having a grasp on the fundamentals of astronomy. To be sure, this is not as widely accepted as it should and will be. The pattern-cut, free education that is handed out these days apparently accords more value to memorizing the list of State capitals and details of Revolutionary battles than to an appreciation of man's place in the Universe and the facts which may lead to a better understanding of the Great Scheme of things. Fortunately, this attitude no more affects the relative values in the scale of knowledge than the recent absurd court decision in Tennessee has made Evolution either false or heretical. Fortunately, also, our standards of education are continuously rising; to

our descendants, the general indifference of the "educated" of our generation to such an important subject will seem as incomprehensible as the inability to write and read upon the part of our "educated" ancestors seems to us.

Fortunately, once more, these fundamentals are simple to grasp. There are many books, all easily readable, that give with a deliberate avoidance of mathematics all that the average reader needs to know. It is hoped that this book proves worthy to join their ranks.

It was Edwin Arnold who said: "Astronomy will eventually be the chief educator and emancipator of the human race." He felt, with many others, that astronomy is the fundamental science, the most ancient, most uncommercial and most unselfish of all; involving the superlative and supreme manifestations of natural law; and that it is a primary factor in all education.

The history of astronomy is the history of the development of reasoning thought in man, and it contains as well a wealth of romance and human interest.

The achievement of Kepler in substituting the correct curves of planetary orbits for the sacrosanct perfect circle would seem at first but a mere mathematical triumph; but, when it is considered that he attacked and destroyed that most pertinacious of things: a combination of popular superstition, scientific conviction and religious dogma, it appears in its proper light as an example of masterly power and extreme courage.

What a gentle picture astronomical history

brings to us of Halley, who first predicted the return of a comet, the great one which now bears his name. In his own words: "Hence I think I may venture to fortel (sic) that it will return in the year 1758," and, knowing that he could not live to see it, asked modestly only that the world remember its return had been predicted by an Englishman.

And what a sterling old fellow it shows us in Tycho Brahe sturdy and sound in his work, which he approached with such reverence as never to appear in his observatory except in full court dress.

Democritus, Pythagoras, Ptolemy, Hipparchus, Galileo, Leonardo da Vinci, Newton—the great names blazoned on the scroll of astronomical history are legion, and from all ages.

The discovery of Neptune independently by Adams and Leverrier is romance difficult to equal, and is but one instance out of thousands. As one writer expresses it: "Romance? Astronomy offers more thrills to the alert human mind than all the fiction in the Library of Congress could provide."

Von Humboldt wrote: "The stars bind together all men and all periods of the world's history." This is particularly true in connection with the mythology of the heavens; and to quote the late Garrett P. Serviss: "Science has carried us far from the realm of pure delightful fancy which the ancients found in the sky, but the constellations have remained while empires perished and will remain as long as the human imagination lasts. They are the true scroll of mythology,

and the veritable history of the world's youthful days. The facts of the present are not greater than the dreams of the past."

In the more special educational fields, the stimulative effect of astronomy has been, and is, great. Researches in modern physics, chemistry and electricity are based upon the action of the atom and the particles that go to make up the atom; so, as explained in the next chapter, is modern astronomical research; they are all intermingled. Prof. Eddington writes: "It is now well realized that the stars are a very important adjunct to the physical laboratory—a sort of high-temperature annex where the behaviour of matter can be studied under greatly extended conditions." As many of the facts of atomic behaviour have first been discovered and studied in the stars, it will be seen that a proper understanding of present day science depends greatly upon a conversance with the advanced theories of astronomy. Don't think that even this is difficult; Eddington's "Stars and Atoms" reads like a delightful romance; and there are other books of the same quality.

So much for the educational reason.

Recreation, the second of the two reasons, is used in the widest sense of the word, covering intellectual pleasure, enjoyment of sheer beauty, mental relaxation in valuable work that is fascinating to do, and the fun of sight-seeing.

No lover of the out of doors can, or wants to, deny the very real pleasure awakened by the ability to recognize and call by name a bird, a

flower or a tree. There is a sense of satisfaction in being able to do this that is quite separate from any other emotion. The bird may be ugly, the flower a weed, but the fact that you can name it, even though the name be as uneuphonious as some flower names are, makes it of interest to you. You experience a distinct intellectual pleasure. There is the same pleasure in the knowledge that that blue-white diamond in the sky is Sirius, the brightest star to us, or that "there's Orion! Below those three stars is the great nebula."

If you don't believe it, step out of doors on a clear night, away from artificial light, and gaze upward at the firmament. Carry with you a flashlight and an elementary guide to the constellations—this book or any of the many others. In a few moments you will be recognizing the time-honored figures placed in the heavens by the imaginations of ancient peoples, and identifying, one by one, the stars and their exotic names. Go out again the next night *at a different time* and find your newly-made friends, now in another section of the sky. You will enjoy the very *finding* of them and the *naming* of them. Soon you will know almost instinctively where and when to look for them and will discover yourself doing it even unconsciously whenever you step out at night. If the sight of the first robin or the first crocus in Spring brings you delight, be assured that *recognizing* the return to our night skies of the beautiful Spica will bring you as much.

And remember this; "Astronomy offers one of those pleasures which follows the law of in-

creasing rather than diminishing returns. The more you develop it, the more it gives you back. There is no season of the year when the interest ceases; and no time of life, so long as sight remains, when we are too old to enjoy it." To this might have well been added, "No matter where you are."

It was Carlyle whose plaint rings through the years: "Why did no one teach me the constellations when I was a child."

As far as beauty is concerned, the writer can but ask you to use your eyes and listen to those who have.

To quote from Emerson: "If the stars should appear one night in a thousand years, how men would believe and adore and preserve for many generations the remembrance of the City of God. . . . One would think the atmosphere was made transparent with this design: to give man in the heavenly bodies the perpetual presence of the sublime."

"The spectacle which greets the upturned eye on a clear night is a glorious one, incomparable in sheer physical beauty and enriched beyond words by the grandeur of the actualities revealed through the efforts of generations of patient observers."

Paragraphs like this could be assembled by the thousands.

The contrasting colors of the stars are exquisitely evident to the unassisted eye, but it requires optical aid to reveal their startling beauty. Right here, it may be well to call your attention to the fact that an opera glass or a

field glass is of real value for "star-gazing." With the help of either, sweep over the splendid star fields where the Milky Way crosses the constellations of Cygnus, Sagittarius and Scorpius, and you will behold a vision of loveliness that is exalting; then, perhaps, for the first time you will glimpse the full meaning of the word "glory." With a small telescope, the veils of distance are still further removed. You will gasp at the diamond-cluster of the Pleiades, and stare in amazed delight at some of the jeweled double stars, such as Albireo of Cygnus, a topaz sun with its pendant blue companion.

When you have truly familiarized yourself with the constellations and the positions of the stars—which is a knowledge quickly and easily acquired, for there are only about fifty constellations visible in the latitudes of the north temperate zone—then there is a wider field of interest opened to you. You will enjoy watching the night by night movement of the Moon *eastward* through the stars, and tracing out the slow majestic processions of the planets in their "wanderings" which so perplexed the ancients to explain.

You may discover a Nova, or new star, one of those riddles of the universe. Dr. Anderson of Scotland secured enduring fame by discovering two important ones with the naked eye, simply making it a practise to observe the heavens carefully during his nightly exercise-walk.

Then, too, there is a practical and scientific research work of decided value, that can be done

only with the naked eye. This is the observation of meteors. Here is an opportunity for anyone to contribute his or her mite to the progress of science. Further reference to this work is made in the chapter on meteors.

Now, if you are alive to beauty, if you have an intellect that is active and alert, if you are endowed with curiosity, if you yearn to explore further regions of the Universe, to view objects superlatively wonderful and mysterious, you will long for a telescope and the revelations of that wonder glass. Only a "three-inch" instrument is required to reveal literally thousands of celestial objects never seen with the unaided eye. The telescope kindles an interest that never pails. Its use awakens emotions of amazement, admiration and awe as does nothing else in life. The first telescopic views of the Moon, the rings of Saturn and the moons of Jupiter are positively startling, while the wonder of a giant swarm of suns like the cluster in Hercules is astounding.

The writer can speak from experience in saying that there is no greater relaxation than leaving behind the Earth and its cares to embark on a celestial sight-seeing trip with a three-inch glass, except that of combining such a trip with fascinating work.

Many, probably most, people, even some who are the happy possessors of an instrument, believe that with the wealth of observatories in the world, and the magnificent equipment at their command, nothing of scientific value to astronomy can be accomplished with a small glass. Such, fortunately, is not the case.

There are in the heavens thousands of Variable stars, stars that fluctuate in brightness. The law governing most of these fluctuations is unknown and presents a baffling enigma. Only by recording hundreds of thousands of observations can we hope to solve the mystery.

The American Association of Variable Star Observers was founded in 1911. It now has 350 members, scattered all over the world. The members for the most part are amateurs with small telescopes. During the past seventeen years these observers have contributed 250,000 observations, all of which have been published and filed with every observatory in the world, a record of amateur endeavor and achievement unequalled in any other branch of scientific research work.

The observation of the long period Variable Stars has now been turned over to the members of the Association by professional astronomers. Here then is the opportunity for anyone with a small instrument to engage in research work that is of scientific value and intellectually profitable. "Every observation with a definite purpose becomes a new adventure."

All that is required for Variable Star observing is a small telescope of three-inch aperture or larger, and a knowledge of the constellations. *No mathematics are involved*, and the details of the work are quickly and easily mastered.

What other research work offers such an opportunity to the layman? Score another point for the attractions of astronomy.

While it was promptly admitted that a knowl-

edge of astronomy was of no practical use to the average man, it should be clearly understood that this great science has been, is, and always will be of inestimable *material* use to mankind. Let us consider how the accumulated knowledge has been used:

First: Time, in ancient days and in the present, is derived from stellar observations. Thanks to the invention of devices and instruments of great precision and refinement, we are able to correct time to the hundredth part of a second. No other factor outside the actual physical needs of man surpasses in importance this feature of human existence.

Second in importance of the practical service that astronomy renders mankind, is the application of the science to Navigation. In ancient times, the early Phœnician navigators relied entirely on the North Star as their faithful and reliable guide, and ever since that date the star Polaris has proved of like value to those who wander in far places.

Today every ship that sails the seas depends on the data contained in the Nautical Almanac in order to derive its correct position, and sextant sights on the stars are frequently taken by the officers of all the transatlantic liners.

All marine navigation, therefore, except by dead reckoning, is dependent upon the work of astronomers.

In aviation, there is a like application of the science of astronomy in the navigation of airplanes and dirigibles. It is of prime importance to those who attempt transatlantic flights, for

the compass is not always to be relied upon.

Third: Our land, and through its acquisition, all the elaborate property system that has been evolved, including those all-important factors, territorial, state, and national boundary lines, is dependent on surveying, which in turn depends for accuracy on astronomical observations.

Fourth: A further application of astronomy of the greatest practical value is our knowledge of the action of the tides, due to the gravitational influence of the Moon. A thorough knowledge of the Moon's mass and motion has enabled us to predict with great accuracy the daily tidal fluctuations the world over. This knowledge has proved time and again of paramount service to mariners in all ports of the world.

Fifth: The rate of speed of light, discovered by Römer three hundred years ago through observation of the moons of Jupiter, was a discovery of signal importance. It finds its application in all that pertains to the study of optics, an all important factor in daily life.

X-rays, and wireless telegraphy, those boons to mankind, are derivations of this discovery, for their waves are but forms of invisible vibrations, of the same general nature as visible light, and moving with the same rate of speed.

Broadcasting (boon or curse, as you will) is, of course, but a descendant of wireless.

As previously cited, the stars offer us opportunities to study matter "in the raw." A comparatively recent discovery has caused some decided changes in our ideas of matter, and this in turn may be productive of practical results.

Further, there is every reason to suppose that the study of sun-spots and solar radiation, now being carried on with instruments of the highest refinement, will yield facts of vast importance in their application to meterology and climate.

Astronomy has destroyed an oppressive mass of superstition. Five hundred years ago a total eclipse of the sun was an appalling event, and was generally regarded as terrifying evidence of God's displeasure. Now the phenomenon is hailed with delight as offering an only too infrequent opportunity for the acquisition of more knowledge. In ancient times, the appearance of a comet in the heavens portended evil to mankind—it was an omen of war, of pestilence, of famine. (Had there been stock markets in those days, the breaks would have been calamitous!) Now we know a comet to be merely a somewhat erratic, but on the whole well behaved, member of our solar family, whose threatening tail could be comfortably packed in a suitcase.

Aside from all the practical attainments of astronomy, the opportunities of discovery, the æsthetic and cultural values it offers, there is another important reason why one should turn to this Mother of Knowledge.

"The new astronomy can lay no claim to afford us material help in the routine of daily life. Her sphere lies outside the earth. Is she less fair? Shall we pay her less court because it is to mental culture in its highest form, to our purely intellectual joys that she contributes? For surely in no part of Nature are the noblest

and most profound conceptions of the human spirit more directly called forth than in the study of the heavens and the host thereof."

She teaches us perspective and "perspective always broadens the soul, and relieves the sharp strain of human self-consciousness. The study of history plunges the mind into despair, or excites to desperation. Nature presents in the animal and vegetable world the same ravening forces. But as we meet her in the stars she is pinnacled. The expanse, the wonder, the sublimity of the objects there, tranquilize the spirit and balance the understanding."

"The stars have a balm for us if we will but be silent; for the huge and thoughtful night speaks a language simple, august, universal."

> "'Tis Nature's system of divinity
> And every student of the night inspires.
> 'Tis elder scripture, writ by God's own hand:
> Scripture authentic! uncorrupt by man."

"First of all we assert that the universe is spherical; partly because this form, being a complete whole, needing no joints, is the most perfect of all; partly because it constitutes the most spacious form, which is thus best suited to contain and retain all things; or also because all discrete parts of the world, I mean the sun, the moon and the planets, appear as spheres; or because all things tend to assume the spherical shape, a fact which appears in a drop of water and in other fluid bodies when they seek of their own accord to limit themselves. Therefore no one will doubt that this form is natural for the heavenly bodies." From *De Revolutionibus Orbium Celestium*, Nicholas Copernicus (1473–1543).

FOR THE BEGINNER

If the reader finds in this short chapter statements so elementary that they affront his intelligence, let him please remember that there are today, as always, thousands of the well-lettered whose knowledge of astronomy begins and ceases with the fact that the Earth "goes around" the Sun. If on the other hand, he be chagrined by his ignorance of these simple astronomical facts, let him find solace in that many of the great minds of the world have not been any the wiser. It is but a moment ago that the Sun went round the Earth, that each star was "fixed," except when hurled from Heaven as a "falling-star," and that "fiery-haired" comets were portents of evil. Indeed, has that moment passed for most of the world today?

With this short apologia we begin *at the beginning*.

Rushing through space, bound whither we know not, save for the mere direction, speeds the vast globe called the Sun, at a rate of nearly twelve miles per second. Around this falling body—and a true and stupendous fall it is—a great multitude of smaller bodies, ranging from tiny particles to huge masses thousands of miles in diameter, revolve with a marvelous regularity and order. This is the Solar System. Although

almost inconceivable in size, its huge dimensions shrink to microscopic estimates when we measure on its every side the unbelievable depths of space that bound its isolation. For countless centuries, the Sun and his family have been approaching at a speed of over a million miles a day, a definite section of the Universe, and yet it seems no closer than it was thousands of years ago. In truth, the Solar System is but a cluster of tiny motes dancing in the infinite.

It is on one of these tiny motes that we dwell, and from its whirling surface gaze in wonderment into the surrounding immensity we call the sky.

What do we see in the sky? It may be well to enumerate at once the various types of celestial objects. They are, in order of their evidence to the eye: Stars, Planets, Satellites, Meteors, Comets, Star-Clusters and Nebulæ.

We have left out the Sun and the Moon and the Milky Way? No! These all are included in the classification as given.

STARS. What is a star? A star is a *sun*. It is a huge spheroidal body of glowing metallic vapors and gases, in widely varying combinations, emitting intense radiations of energy mainly manifested in the forms of light and heat. Our Sun, therefore, is a *star*—the nearest star to us—upon whose proximity depends our very existence.

Aside from this somewhat important result—important to us at least—the nearness of the Sun holds an added value. From an intensive study of this close-by star we can, and have

already, added greatly to our knowledge of its far-lying brethren whose light reaches us from incomprehensible distances.

PLANETS differ from stars in that, while the latter shine with light of their own, the planets merely reflect the light of the parent suns about which they revolve. Our Sun is the only star which can definitely be said to possess a family of planets, as the vast distances of even his comparatively near neighbors in space prevent us from determining whether or no they, too, have planetary attendants. It seems somewhat against the doctrine of chances, however, that among all the many millions of stars the solar system should be unique.

The word "Planet," nevertheless, is used only when referring to one of the eight larger bodies, of which the Earth is one, which revolve about the Sun and shine by reflecting his light. Two of them—Venus and Jupiter—are those which periodically beautify our skies as the Morning- and Evening- "Stars."

SATELLITES, or moons (the Moon is the one satellite of our Earth) revolve about the planets. They, also, shine only by reflected sunlight, so that it is safe to say that, with a minor exception or two, all the light we can ever see in the sky is sunlight, or starlight, the terms being synonymous.

METEORS are odd bits of metal (mostly iron) and stone that sweep about the Sun in orbits that meet the path of the Earth. When they encounter the atmosphere of the Earth it is at such speed that the friction of the air raises

them to a white heat, and we see their luminous path. They are *not* falling stars! This light is one of the exceptions mentioned above.

COMETS are bodies which appear from time to time as ill-defined patches of light, from which often extends a long tail. Most of them, probably all, are members of the solar system, and revolve in regular orbits about the Sun. Most of these orbits are very eccentric ellipses, or elongated ovals. A large part of their light is reflected sunlight, but, as some of it is not, they constitute the second exception to the universality of starlight.

STAR CLUSTERS are vast *swarms of suns.*

NEBULÆ may for our purpose be divided into two broad classes:

> *Diffuse Nebulæ* (of which there are several subdivisions) vast masses of gases; some dark, and defined only by the light of the stars behind them; some luminous, probably for the most part by reflected starlight.
>
> *Spiral Nebulæ*, which are "Island Universes" remote from our own stellar system, and comparable in size to it.

It is greatly to be regretted that the scope of this book will allow no further discussion (except for the notes in the text accompanying the constellation charts giving the positions of some of these marvellous systems) of the Clusters and the Spiral Nebulæ. There is space to say only that our knowledge concerning them is making great strides and that every step adds to their vastness and their importance in the "great

THE HERCULES CLUSTER

This magnificent object is just visible to the naked eye. It is estimated to contain not less than 100,000 Suns. *See description on page 212*

From a photograph taken at Astrophysical Observatory, Victoria, British Columbia

scheme of things," and pushes farther away the boundaries of the Cosmos.

We now know much concerning their constitutions, their sizes, their distances, and their speeds relative to ourselves. As examples: the Cluster in the constellation Hercules (just visible to good eyesight, easily found with an opera glass and a fine sight in a small telescope) is a vast assemblage of "over 100,000 stars" approaching the Earth at 200 miles a second. "Even at this terrific speed, it will take at least a billion years for the cluster to arrive." (Dr. E. S. Frost.) The Andromeda Nebulæ is approaching at about the same speed. Its light takes one million years to reach us and yet it can be easily seen with the naked eye. Conceive, then, its size and true brilliance. This nebula "is presumably one of the nearest of the spirals." (Eddington.)

THE MILKY WAY, or GALAXY, indicates the direction of the rim of the stupendous *lens*-shaped aggregation of stars of which the Sun is a member. Being comparatively near the center, we see more stars when looking that way than when looking through the thinner dimension of the "lens." (*See special chapter.*)

It seems best to take up at once several other points in connection with the stars.

STAR MAGNITUDES. Upon looking at the stars, it will be immediately apparent that some are brighter than others. It is upon this fact that one of the classifications of the stars is made, i.e. "magnitude," a classification in constant use.

The term magnitude as applied to a star refers

not to its size or the actual amount of light it gives but to its *brilliancy as seen by us*. The reader is asked to keep this constantly in mind. It is evident, then, that a star's magnitude is the result of two factors, the *true brilliancy* and the *distance* of the star from the Earth.

The stars are roughly grouped as of 1st magnitude, 2nd magnitude, up to about 20th magnitude, the higher numbers denoting the *lesser* brilliancy. Each magnitude is two and one-half times brighter than the preceding one; that is, a 1st magnitude star looks 2½ times brighter than a 2nd magnitude star, 6¼ times brighter than a 3rd magnitude star, and over 100 times brighter than a 6th magnitude star. (*See diagram p. 70.*) For more accurate estimates of stellar brilliancy, the magnitudes have been subdivided into ten parts, and a star may be mag. 5.6 (or five and six tenths) 2.3, 10.9, etc. For our purpose, the broader classification is quite sufficient, and stars ranging from mag. 1.6 to mag. 2.5, inclusive, will be referred to as of 2nd magnitude; stars from 2.6 to 3.5 of 3rd magnitude, and so on.

Betelgeuze (mag. 0.9) in the constellation Orion, Aldebaran (mag. 1.06) in Taurus, and Deneb (mag. 1.33) in Cygnus are good examples of standard first magnitude stars.

It will be noted that Betelgeuze is given a magnitude of *less* than one. This minus scale becomes necessary for a few stars that are brighter than true first magnitude. In this minus scale the relations of the magnitudes is the same; mag. 0 is 2½ times brighter than mag. 1,

and mag. —1 is 2½ times brighter than mag. 0. The brightest star, Sirius, is mag.—1.58.

A 6th magnitude star can just be seen with the naked eye. There are about six or seven thousand stars visible without optical aid, but only about 2,500 of these can be seen at any one time. A good field glass reveals over 50,000 stars, a "3-inch" telescope well over 300,000, and the greatest telescope brings fully a billion within range.

In the appendix are tables giving the numbers of the stars, grouped according to magnitudes, distances, etc. (See *Absolute Magnitude*, p. 53.)

It is a noteworthy fact that the stars which are not visible to the naked eye give us more light than those which are visible!

The matter of stellar distribution is an interesting one. Approximately, there are twenty stars of the first magnitude. Multiplying the number of stars of each successive magnitude by three and a fraction, gives the number of stars of the next fainter magnitude, until the tenth magnitude is reached; then the ratio changes to two and a fraction, up to the 17th magnitude. From the 17th to the 20th magnitude the ratio is one and a fraction, showing that, as we progress outward in space to the fainter magnitudes, there are fewer stars than calculation requires, according to the hypothesis of uniform distribution. According to Professor Seares, the total of all stars fainter than the 20th magnitude is relatively small.

Color of Stars. Until it is pointed out to them, few people notice that stars are of different

colors. There is a wide range of tints easily seen with the naked eye, and the telescope discloses many more of gem-like beauty. The outstanding colors are red, yellow and bluish-white. The spectroscope reveals to us that these colors are closely associated with the "age" of the stars—their positions in the evolutionary scale—their actual surface brilliancy, and their sizes.

SIZES OF THE STARS. We know now that stars are really of different sizes as well as just looking brighter or "larger." They range from the huge giants of many millions of miles in diameter to the "tiny" dwarfs of only thousands. There are a number of methods of determining the sizes, including actual measurement, even though the largest appears in the greatest of telescopes merely as a *point* of light. There is reference to these methods in the next chapter.

In the text accompanying the constellation charts of Orion and Canis Major are given some interesting facts concerning the giant Betelgeuze and the companion to Sirius. In the appendix is a diagram showing the comparative sizes of some of the giants.

Stars of Special Interest

There are in the skies many stars which seem to the casual observer to be just "everyday" stars, like all the others. Close study with the naked eye will in some cases, and observation with the telescope in many, reveal that they possess varied characteristics.

These stars may be divided into the following

classes: Double and Multiple Stars, Binary Stars, Variable Stars, and New or Temporary Stars.

Double Stars. There are many stars seemingly single points of light to the naked eye which, with the aid of a telescope, may be resolved into two or more stars. In some cases this is merely the result of perspective. Two stars nearly in a line when viewed from the Earth, will, although billions of miles apart, one farther away from us than the other, appear side by side on the celestial sphere. In many cases, however, the stars are actually close together.

Many of these double stars show beautiful contrasts in color. The star Beta in the constellation Cygnus, for example, can be separated into two by even a small glass, the primary a brilliant topaz, and the smaller star a wonderful peacock blue. In fact, this color contrast in double stars is the rule rather than the exception, although some of the famous doubles are of the same shade.

Multiple Stars are not nearly so numerous as simple doubles. There are many known, however. The sextuple star in the heart of the Orion nebula is the best example. A small telescope shows this as four stars only, placed in the form of a trapezium, but a large instrument adds two more to the group.

The small naked-eye star Epsilon of Lyra is just separable by a good eye. A telescope again divides each component, showing a system of four stars. (See diagram p. 75.) The observation of Double Stars is one of the pleasures

offered the owner of even a small instrument.

BINARY STARS are merely double stars whose orbital revolution about each other has been proven. They are, as a rule, much closer together than the average "double."

Many stars that defy separation with a telescope yield their secret to the spectroscope and are proven close doubles. These, in consequence, are called spectroscopic binaries. Each component of the telescopic double Mizar of the Great Bear has been proved to be a double, though no telescope will ever be able to show the four stars.

A VARIABLE STAR is one whose magnitude changes from time to time, these changes being in some cases slight and in others very great, and occurring usually in a comparatively regular cycle.

The variables are generally classified as "short period," those whose cycle is completed in a few days or less, and "long period," those which require more time, in some cases even years.

The SHORT-PERIOD VARIABLES may be subdivided into those whose variation is caused by a partial eclipse of the brilliant star by a companion star—close binaries, of two stars revolving about each other; and those where the variation is due to some real change in the star itself which alternately blazes up and smolders, or pulsates; why, we don't definitely know.

The best known example of the former class is the star called "Algol," which shines in the constellation Perseus. With great regularity, every two days twenty hours and forty-eight

minutes, the light of Algol undergoes a rapid change, first decreasing over a magnitude, and then regaining its full brilliancy, the duration of the whole phase being nine hours and twenty minutes. This means that at maximum the star gives over twice as much light as it does at minimum. This peculiar behavior of Algol has been long known, and its name, signifying "The Demon," shows the riddle it propounded to the Arabs. By the aid of the spectroscope, this riddle was solved, and it is now known definitely that Algol is a system of two stars, one bright, the other comparatively "dark," and invisible even with the aid of the great telescopes. These revolve about each other—that is, around their common center of gravity, as do the Earth and Moon—in a period exactly equaling the cycle of Algol's variation in magnitude. It is the passage of the "dark" star between us and Algol which, by partially eclipsing the latter, cuts off from us much of its light.

Constant observation has, in the past few years, added many variables to this "Algol type," most of which are almost faultless time-keepers.

The second subdivision is of far more interest, containing a type of star which has enabled us to estimate closely the distances of the nebulæ and clusters, as explained in the next chapter. This type is known as a Cepheid variable because the first of its kind was located in the constellation Cepheus.

Professor Eddington says of the Cepheid variable: It "is a single star which pulsates. It is a

globe which swells and contracts symmetrically with a regular period. And as the globe swells and contracts . . . the issuing stream of light rises and falls in intensity. . . . There is no question of eclipses."

Of LONG-PERIOD VARIABLES many are known. Some of these pass through their changes with a real regularity, while others are so erratic that no period or cycle can be stated. In fact, these irregular variables seem to scorn any degree of constancy, and the maximum of one rise may fall far short of previous brilliancy. The extreme rapidity with which some of these freaks "rise" is astounding. In some cases only a few hours is necessary for one to rise to a maximum fifteen or twenty times more bright than its minimum.

The most noted long-period variable is Mira, "the Wonderful," of the constellation Cetus. This has been under observation for over three hundred years, and is the first of these stars to be recognized. In the course of about 331 days Mira changes slowly and evenly from a star of over second to one of less than ninth magnitude, and back again; so that, while at maximum it is one of the most conspicuous stars, it is for over five months of its cycle invisible to the naked eye. It gives at maximum about 375 times as much light as at minimum.

By careful study of these long-period variables it has been possible to classify many of them according to their "light-curves," and continued observation and spectroscopic study will without doubt discover the causes for all the various peculiarities.

New Stars. Occasionally the careful observer of the skies will note a star where previously none, or only a very faint one, was to be seen. This is called a new star, or technically a Nova.

The causes of these sudden appearances, for sudden they indeed are, are not definitely known, but it is certain that they are evidences of some enormous cataclysm. It is generally accepted that a Nova is the result of a collision of some sort between two celestial bodies. There is also the possibility, which science is now finding not so improbable, that a Nova shows to us the actual explosion of a star by atomic disintegration.

New stars seem to pass through about the same general changes. They flash up from nothing to widely ranging degrees of brilliancy, some never being visible to the naked eye, and others being, for a time, the most conspicuous of the stellar host. Their maximum brightness is held for a comparatively short period, and they then fade slowly, occasionally blazing up briefly as if in vain attempts to retain their passing glory. The decrease, however, is always great, and a Nova, as a rule, either entirely disappears, or remains as a very faint, and often nebulous, star, usually a variable.

In the appendix there are tables of the dates of famous Novæ.

The "Twinkling" of a Star

Many people ask why a star "twinkles." This is entirely caused by the refraction and disturb-

ances in the Earth's atmosphere. Were this removed, the stars would blaze steadily in a deep *black* sky with a glory never to be seen from the Earth's surface. The planets do not twinkle, as the beams of light coming from them are comparatively "thick" and sturdy, while such are the distances of the stars that but the tiniest thread of their light reaches us; so tiny is this that the slightest disturbance of the air causes enough refraction to make the light flicker. A planet close to the horizon, when its light must penetrate more and denser air, most of which is in a greatly disturbed condition, *will* be seen to flicker as does a star. The planet Mercury which is never seen far above the horizon is sometimes spoken of as the "Twinkler."

The "Light Year"

The distance between our system and the stars is so tremendous in extent, that astronomers selected the "Light Year" as a unit to express stellar distances. This is the distance light travels in one year at the rate of 186,000 miles per second, approximately six trillion miles.

Even this unit is too small to express conveniently the distance separating us from some of the nebulæ and globular star clusters that lie on the frontiers of the visible universe. The unit of measure used by professional astronomers to express these distances is the "Parsec," which equals 3.258 light years, and which is explained in the next chapter. (*See Note p. 39.*)

The bare statement that light travels at the

rate of 186,000 miles a second conveys very little to the average mind. We are utterly unable to grasp the significance of the fact, unless we apply an illustration of some sort, and step the distance down, so to speak. Let us imagine that we are borne on the wings of light for a series of journeys. First, we should take a trip around the earth, which we would accomplish in *one-eighth of a second;* then to the Moon, which we would reach in 1.2 seconds. A journey to the sun would be made in eight minutes, and one to distant Neptune in four hours, Neptune, you must know, being 2700 million miles from the earth. To reach the *nearest* star would take four and a half years; to reach the farthest . . . ?

It certainly was in the very earliest days of humanity that the Sun, Moon and the stars attracted the attention of man. The first use that he would naturally make of the heavenly bodies would be for the determination and measurement of time, that all important factor in our lives.

The diurnal progress of the Sun across the heavens would enable him to divide the day into time intervals, and the Moon and the stars would serve a like purpose at night.

Lunar calendars were devised by the Chinese, Hindus, and the primitive races of Central and South America at a very early date in the history of the human race, and even before that time the stars had been associated in the groups that we call "constellations." To these groups were assigned, arbitrarily enough, boundary lines that

enclose what, with marvellous imagination, these ancients saw as figures of gods, heroes, animals, reptiles, etc. These time-honored constellations have come down to us (even professional astronomers use them in designating the positions of stars), and the many curious myths and legends connected with them enhance greatly the pleasure in the study of stars.

It is the identification of these constellations, and the memorizing of their positions in relation to each other that may well be the first steps in observational astronomy.

In beginning the study of the heavens, it will be immediately evident that the stars seem to move. As a matter of fact, every star *is* in rapid motion, but we do not see these real motions. It is only the seeming motion that we must allow for—the *apparent* motion of the stars across the sky from east to west. This is caused by the rotation of the Earth upon its axis; as the Earth turns eastward the stars appear to move westward. In short, it seems as if we were in the exact center of a hollow sphere of which we can see but the half above us, the other half being shut from view by the Earth beneath. Upon this sphere are fixed points of light, the stars, which *do not change their positions relative to each other*, but which rise in the east, pass across, and set in the west as the great sphere turns above us.

In astronomy, this apparent sphere is *treated as if it were an actual one*, and is called the *Celestial Sphere*. Upon it are figuratively ruled

circles like the latitude and longitude markings upon a geographical globe, and the exact position of a star can be designated as easily as the position of a spot upon the Earth. (*See p. 38.*)

This apparent motion has one result that is likely to prove a little confusing to the beginner. A constellation—Orion, for instance—will rise lying on its east side, be upright as it passes to the south of us, and set lying on its west side. The four season plates make this clear.

The stars rise about three minutes and fifty six seconds *earlier* each night (about two hours earlier each month), as will be evident from but a few weeks observing. This is caused by the orbital motion of the Earth about the Sun.

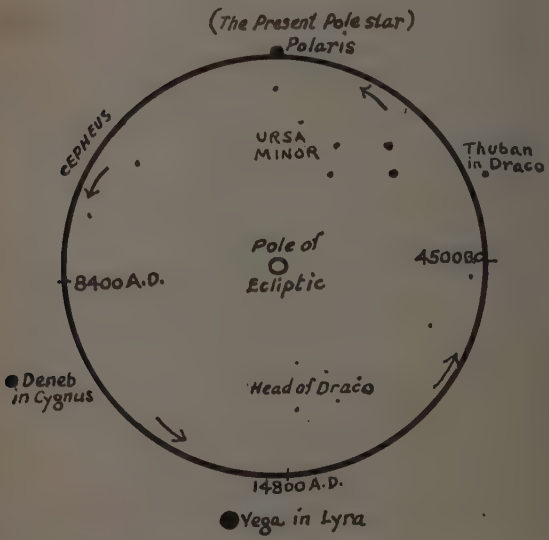
The *real* motions of the stars, which do not properly concern us here, are:

Proper Motion; that is actual motions across the line of sight on the night sky. These motions, although often very great, and at terrific speeds, are, because of the distances of the stars from us, not noticeable to the ordinary observer, to whom the stars appear "fixed," and can be measured only by delicate instruments. In the Appendix will be found some of these determinations, together with some of the

Radial Motions of stars, radial motion being the movement of the star in the line of sight, its velocity of approach or recession.

There is another *apparent* motion, but a very slow one, amounting only to one degree of arc in about seventy-two years. The rising place of each star on the horizon moves to the right, or

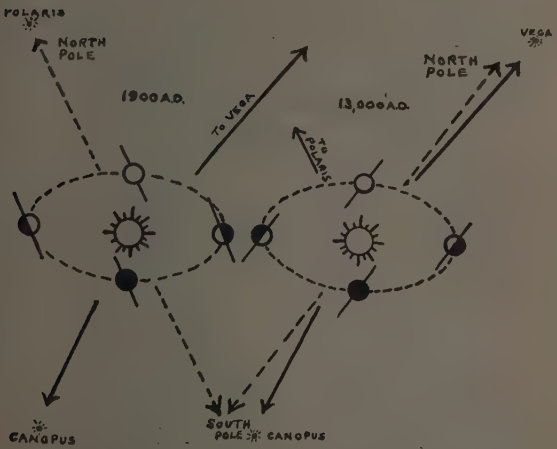
clock-wise. This is caused by a special movement of the Earth as it revolves in its orbit about the Sun. This motion is a wobbling, like that of a "dying" top, so that the axis of the Earth would, if it were extended, describe a large circle on the celestial sphere. It takes about twenty-six thousand years to complete this circle.



Circle described on Celestial Sphere by the axis of the Earth.

This movement is called the Precession of the Equinoxes, and results in a change of our seasons, and of our North Star. About three

thousand years ago, the star Thuban, in the constellation Draco, was our Pole Star. It is interesting to note that the large slanting passage in the Great Pyramid was built to point directly at this star. Twelve thousand years hence, Vega, the brightest star in the constellation of Lyra, will be our North Star, and our summer will come in what are now the winter months.



The axis of the earth as it (left) points now and as it (right) will point when half way through its revolution.

This Precession of the Equinoxes is "due to the gravitation of our Sun and Moon upon the bulging equatorial belt or zone of the Earth, combined with the centrifugal force at the Earth's equator."

RIGHT ASCENSION AND DECLINATION. On the celestial sphere, spoken of previously, there are three systems used to designate the position of an object: the horizon system, the ecliptic system, and the equator system. For a detailed exposition of these systems the reader must be referred to one of the text-books listed in the bibliography.

There need be briefly explained here only the one more commonly used—the equator system.

On the earth, we locate a point by its longitude, east or west of the Greenwich observatory which is longitude 0, and by its latitude north or south of the equator. The lines of longitude all are great circles passing through both poles of the Earth and the lines of latitude are all parallel to the equator.

On the celestial sphere the equator system is exactly similar. Position is measured *eastward* from the celestial "Greenwich": the vernal equinox, which is the point where in spring the Sun is on the celestial equator. Instead of speaking of longitude, the distance from this point is given in degrees or hours of *Right Ascension* (R. A.). The position north or south of the celestial equator—which like the earth's is an encircling line mid-distant from the poles—is given in degrees of Declination (Dec. or D.).

Right Ascension is usually measured by a clock so that it is, therefore, more convenient to express it in time rather than in degrees of a circle. There are 360 degrees to a circle and the celestial sphere rotates in 24 hours of time. It will be seen that one hour of time expresses the same distance as 15 degrees of arc, and that four min-

utes of time equals 1 degree of arc. It is a simple matter to turn the time measurement into degrees or vice versa. The position of the star Betelgeuze, for instance, is usually written R.A. V^h $50^m.8$ Dec. N. 7°24′ which says in effect that the star rises just that number of hours after the Vernal Equinox. This can be equally well expressed by R.A. 87°2″.8 Dec.N.7°24′.

Declination is sometimes written + or − instead of N. or S., or is even merely underlined or printed in italics if the Declination is *South*.

It is of great convenience in observing if the Right Ascensions of several of the bright stars are known; these will give starting places for measurements. There is a table of these in the Appendix. It is always easy to estimate the declination of a star by its distance from Polaris.

NOTE.—As this book is ready for the press, the attention of the author is called to a new unit of measurement—the mega-parsec, or great parsec. This is equivalent to 1,000,000 parsees, or 3,258-000 light years. This tremendous unit is found necessary to express in figures of convenient length the distances of the far-lying spiral nebulæ. The mega-parsec might be called the inter-universe unit.

HOW DO WE KNOW?

Throughout this book, the reader will find statements concerning the celestial bodies—their distances, their sizes, etc., that may easily awaken the doubt: "Aren't they just guessing? How do they know?"

Such a doubt is but natural. It is almost incredible that man could have acquired definite knowledge of the movements, the volumes, and even the constitutions of bodies at such stupendous distances. Indeed, it was less than one hundred years ago that a retiring Astronomer Royal expressed in his valedictory speech his deep regret that astronomical advance must cease, that a limit impossible to pass beyond had been reached. Yet, it is since his time that most of the great steps in astronomical learning have been made.

It is also not unnatural that there should be a tendency to scoff at astronomical figures. Temperatures that run into the millions of degrees, speeds reckoned in many miles per second and distances so vast that special scales to express them must be devised, since in terms of terrestrial measurement they resolve into absurd and incomprehensible figures, all tend to arouse a somewhat scornful disbelief. Let the scoffer realize and remember this: his standards of com-

parison are wrong! He looks upon conditions as he knows them on the surface of the Earth as the usual, the normal, state of affairs. They are not—they are *most exceptional!* Relative to the general conditions of matter as it exists throughout the universe—truly almost universal conditions, and therefore the *normal* ones—our mile-a-minute, our two hundred miles an hour are near approaches to immobility; our greatest distances are but microscopic scratches on the inter-stellar scale; and, considering that probably nine-tenths of the matter in the universe is at temperatures of over a million degrees (Eddington), our familiar temperatures are very near to absolute zero.

Let him also remember that he cannot trust his own senses! In fact, Nature seems almost to have planned to mislead us by these senses, for, when it comes to the relation of man and the Earth to the rest of the cosmos, they invariably supply the wrong information! We *see* the Sun rise, and the heavens wheel above us, each star a fixed point of light upon a great inverted bowl; we watch the Moon change shape during each month and *feel* that we are at rest upon a stationary, flat, and solid Earth. *Not one* of those things is true, and the list of such deceptions of which these are samples is a very long one.

To give in a book of this kind and size a detailed description of the methods used in various astronomical measurements, or to present in full different theories, the means by which

they were evolved and the evidence concerning them, is neither fitting nor practicable. This chapter, therefore, will attempt only to indicate the way the modern astronomer and astrophysicist works. It is hoped that it will answer most of the questions that the general reader will ask.

It may be well to point out immediately that practically all astronomical research is now done with the aid of the photographic plate. In the first place, this makes immediately a permanent record which can be studied at leisure and measured with great accuracy, and in the second it is sensitive to "light" that has no effect upon the eye. Also, the long exposure has the advantage of being able to store up the cumulative effects of the light from very faint objects until it acquires enough to make images of them. This the eye cannot do.

> "Then felt I like a watcher of the skies
> When a new planet swims into his ken"

can scarcely be said to apply now. The telescope is turned into a camera, the astronomer into a photographer, laboratory-worker, mathematician and philosopher.

Possibly the most paradoxical thing about modern astronomy is that our knowledge of the overwhelmingly great is acquired from the study of the ultimately small. What we know about the stars has been learned from the study of their atoms. How do we see these atoms to study them? We don't; but they are constantly

THE PLEIADES

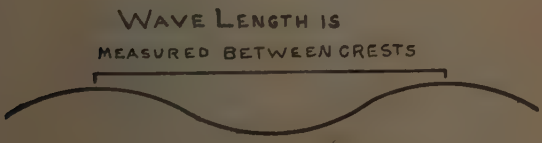
A long exposure photograph showing the wonderful nebulosity enveloping this whole group. Viewed with the eye these stars here shown drowned in foggy light shine clear and brilliant

From a photograph taken at the Yerkes Observatory

sending us messages of what they are doing, and what we call light is their messenger. It may be well to try and explain briefly what light is.

Each atom of matter throughout the universe is in a constant state of agitation, absorbing or radiating "energy." Just why this should be so, or just what energy is, remains unknown; and there seems to be but little probability of our ever finding out. But we can measure energy, and we can harness it and use it; all, that is, that escapes or is radiated from the atoms. It is the dream of scientists to tap and to control the vast store which the atoms never release.

Energy waves spread out from their sources as the waves on the surface of a pond spread out in circles from the spot where a stone has been thrown. Energy waves are of different lengths—that is, the distance from wave-crest to wave-crest may be longer or shorter—but, as



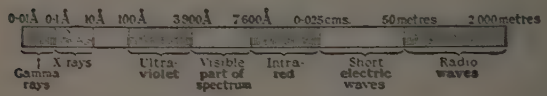
far as we are concerned, the speed at which the waves travel is constant and the same, namely 186,000 miles per second.

When radiations of energy strike the retinas of our eyes, they produce, provided they are of wave-lengths between certain limits, an effect

upon our nerves which we call light. The longer wave-lengths give us the impression of red; the shorter, of violet; and between the two extremes all other possible tints. A combination of all visible wave-lengths produces white light.

There are energy waves far longer than the red light-waves, and just as evident to us in other ways—as heat, radio-waves, etc.—but invisible; and shorter than the violet are more frequent radiations—the actinic rays, the X-rays etc.,—which a photographic plate can "see" but which we cannot. Do not think that we cannot feel their effects, however. Anyone suffering from an intense sunburn is a living and painful demonstration that we do.

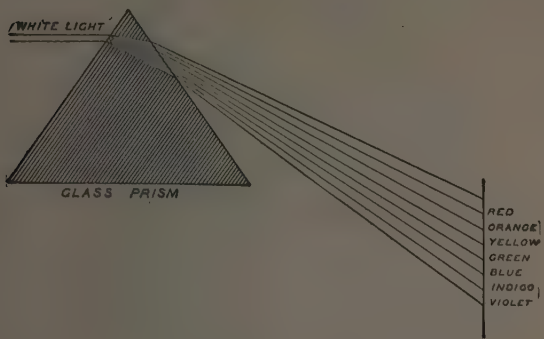
The diagram shows the relative positions and lengths of some of these energy waves.



Far shorter than the Gamma Rays are the Cosmic, or Millikan Rays, ranging in length from 0.0004 Å to 0.00067 Å.
Å the symbol for ANGSTRÖM = $\frac{1}{10,000,000}$ millimeter.

As long ago as 1666, Newton showed that sunlight was a blend of colors. The rainbow presents this light broken into its component parts. Newton demonstrated that a glass prism would do the same thing, and would spread out the light into a "spectrum," bending all the light, but bending the shorter violet waves the most and the longer red waves the least. This fact is the basis of the most wonderful instrument

ever devised by man—the spectroscope—without the aid of which our knowledge of physics and astronomy could never have reached its present stage; for it is with the spectroscope that we read the messages of the atoms, whether in the stars or in the laboratory.



Dispersion of Light.

The principles of the spectroscope are:

Different forms of matter give different kinds of light, and each form of matter has a spectrum *as individual as a finger-print.* Every spectrum is crossed by certain lines, each line, or series of lines, being produced by the light of one element and *by no other;* and these lines *always appear in the same relative positions.* It is not within the scope of this volume to describe the details of spectroscopic analysis, but the reader is asked to accept it as an accurate science used as much, if not more, in practical physics and chemistry as in astronomy. A skilled spectroscopist is able to say immediately, upon seeing a clear spectrum,

that it was made by light coming from certain specific materials, and from those only, for an exact knowledge of what substances produce certain spectrum lines has been built up from actual experience in the laboratories.

It is possible, therefore, to tell from the spectrum of a star what kinds of matter are most in evidence in that star.

In connection with this, it is interesting to note that helium (now so well known as the desirable gas with which to fill the great dirigibles) was discovered in the Sun (hence its name, from the Greek *Helios*, meaning sun) more than thirty years before it was found on the Earth. Its lines were present in the solar spectrum, but not until helium had been isolated on the Earth was it possible to reproduce these lines in a laboratory.

Also, in the spectra of some of the gaseous nebulæ of a special classification, there was found an unknown series of lines. For years this was thought to indicate an undiscovered element, and it was named Nebulium. Later evidence has, however, established a limit in the number of elements that can exist, and this suggested that the series of lines was probably generated by some combination of known elements in unusual conditions. Eddington, writing in 1926, said: "But Nebulium is not a new element. It is some quite familiar element which we cannot identify because it has lost several of its electrons. An atom which has lost an electron is like a friend who has shaved off his moustache; his old acquaintances do not recognize him. We shall

recognize nebulium some day." In the autumn of 1927, Dr. Bowen proved that nebulium was a mixture of oxygen and nitrogen in a special condition, and Eddington now writes: "Confidence that the mysterious substance producing the light of the nebulæ would prove to be quite familiar has been justified; it is *air*."

There is another enigma to the spectroscopist which has not yet been solved, and it may prove more difficult to recognize this "friend without his moustache" as we can see him so seldom. This is "Coronium" which appears only in the corona, that glorious aureole of light surrounding the Sun, and which is seen only during a total eclipse—a pitifully few minutes each century. Who can doubt though that it will be found out despite its disguise? Perhaps, even, the photographs made during the eclipse of a few days ago, May, 1929, have caught the evidence necessary for the identification.

Aside from disclosing to us the secrets of what the stars are made of, the atoms also tell us much about the motions of the heavenly bodies.

Nearly every one is familiar with the way in which the tone of an engine bell or whistle rises in pitch as the engine rushes toward the listener and lowers in pitch as the train recedes rapidly. This, of course, is due to the fact that a definite number of sound vibrations per second striking our ears will always produce to us a tone of a certain pitch. When a bell, giving out that number of vibrations, is rushed toward us at high speed we receive more than the proper number, and the pitch rises above the correct

note; when the bell is carried rapidly from us, a lesser number of vibrations per second reaches our ears, and the pitch is consequently lowered. A similar phenomenon occurs with light. When the source of the light is speeding toward us, we receive more than the normal number of light-waves. As this is the case with *all* the waves, no matter what their length, there is no change in the *relative positions* of the spectrum lines, but the *whole spectrum* is shifted toward the violet, or rapid, end—the pitch is raised. A receding source of light gives a spectrum shifted toward the slower red end. By measuring these shifts it is possible and practical to determine the speed with which the source of the light is moving, and whether away from or towards us. The rotation of the Sun can easily be demonstrated by this spectrum shift. One side of that great body is, in its rotation, approaching us, the other side receding from us, and the center part doing neither. The spectroscope shows this clearly.

It is light, therefore, which laughs at distance, and traverses countless billions of miles unchanged, that brings to us the facts of the Cosmos as betrayed by its telltale atoms; to understand these facts we need only to record the messages and decode them. The spectroscope gives us the key to the cipher.

It may seem strange, but some of the astronomical facts most difficult to prove are those that directly pertain to the Earth and its relation to the universe. It is in connection with these that we come into direct and extreme conflict

with our traitorous senses. The three statements: the Earth is "round"; it rotates upon its axis; it revolves about the Sun, are all quite contradictory to what we see and feel. It is not to be wondered at, therefore, that the evidence in their favor took such a long time to collect, and even now is not universally believed.

THE SHAPE OF THE EARTH is indicated by the circular shadow it casts into space, seen on the Moon during eclipses; by the gradual disappearance below the horizon of a ship at sea; by the fact that it can be circumnavigated, though this in itself is worth little; and is *proved* by the change in the elevation of the stars above the northern and southern horizons according to the observer's change in latitude, and by actual survey on the surface.

THE ROTATION OF THE EARTH is suggested by the impossible speed required for the heavens to complete a daily revolution about a stationary Earth; is strengthened by the obvious fact that all the other members of the solar system are spherical and rotate; and is *proved* by the famous Foucault experiment several times repeated, which showed the Earth turning beneath a pendulum swinging in an undeviating plane.

THE REVOLUTION OF THE EARTH AROUND THE SUN is the most simple way to explain the observed motions of all other celestial bodies. The fact that *all* of the stars—that is all of those who are near enough to show a measurable motion—describe annually on the celestial sphere *exactly similar ellipses* indicates strongly that this is the result of the Earth's describing a sim-

ilar ellipse around the Sun, and that the stellar ellipses are only apparent. In brief, that our senses are again deceiving us. There is direct *proof* of the Earth's revolution in the *aberration of light*, but for an explanation of this phenomenon the reader must turn to a more technical book.

THE MASS OF THE EARTH. Mass is too often mis-spoken of as *weight*. Weight is the measure of the gravitational pull upon the body in question; *mass is the amount of material* that the body contains. The mass of a body does not change with its position; the weight of a body on the Earth varies inversely as the square of its distance from the centre of the Earth. Weight, therefore, as regards astronomy is a misnomer, and we shall speak only of mass.

The mass of the Earth has been determined by measuring its attraction pull on a pendulum, and more accurately by its effect on more delicate instruments using a similar principle. A full explanation requires more than the space available here. The mass of the Earth would weigh at the surface of the Earth some 6.5 *sextillions of tons.*

DISTANCES IN THE SOLAR SYSTEM. These are measured in terms of what is known as the "astronomical unit"—the distance of the Earth from the Sun. To determine this distance it is necessary literally to come to earth, and find something definite to begin from. This something is the diameter of the Earth itself. An attempt to determine this, and a remarkably successful one, was made as early as the second century B.C.

by Eratosthenes—many scientists in those days believed that the Earth was a sphere—but it has never been possible to achieve *absolute* accuracy. However, the margin of probable error is now so small that it can have no serious effect on the calculations in which it is the basic factor.

The diameter is ascertained by geometry from the surveyed measurements of the Earth's size and shape.

With this as a baseline, the distance of the Sun is worked out by triangulation in a method exactly similar to that used by a surveyor in measuring distances on the Earth's surface. The brilliance of the Sun, and several other factors, however, present difficulties that prevent accurate enough results by this direct method, so that another is now used. One of the tiny members of the Sun's family comes very near to the Earth. The position of this star-like point of light is easy to measure by triangulation, and, finding first, by this means its distance from the Earth in miles, and then how much farther away from the Sun it is than the Earth is, it becomes schoolboy mathematics to turn the Earth's distance from the Sun into miles.

From the aberration of light, it is possible to calculate the speed the Earth travels in its orbit. Knowing this and the time it takes to complete its revolution, it is simple to figure the size of the orbit, and from this the radius of the orbit; that is, the Earth's distance from the Sun.

With the "astronomical unit" established it becomes a straightforward matter of surveying —although, of course, very delicate work must

be done—to determine, in terms of that unit, all other distances in the solar system.

STAR DISTANCES. The first measurement of the distance of a star was made by triangulation. In this case, no baseline on the Earth itself could be long enough, and so the diameter of the *orbit* of the Earth was used. A star of large proper motion was picked as being probably comparatively near; this was a small star in the constellation Cygnus (61 Cygni) just visible to the naked eye. Observations were made at one time of the year, and six months later, when the Earth was on the other side of its orbit—in other words at the opposite end of a baseline 186 million miles long—other observations were made. The apparent shift of the star on the celestial sphere, caused by the change in the Earth's position, was measured, the mathematical triangle drawn and the distance calculated. The original measurement, made by Bessel in 1838, was in close accord with the more accurate measurements made since with better instruments. The star proves to have a *parallax*, which is the term for the apparent shift, of .30 seconds of arc (0″.30). This translated into distance in miles becomes a figure without any real meaning; roughly 60,000,000,000,000.. This parallax, by the way, is equivalent to a shift of *one inch* (the diameter of a twenty-five cent piece) seen from a distance of about 11 miles! A measurement of amazing delicacy, yet it is safe to say that parallaxes of only 1/30 of this amount can be detected *with certainty* by modern photographic methods.

It will readily be seen that our earthly unit of a mile is useless for such vast measurements, and even the "astronomical unit" of 93,000,000 miles becomes too small. Astronomers, therefore, were forced to find a unit far greater, and turned to the "light year," explained in the previous chapter. With this standard, we can express the distance of 61 Cygni in comprehensible terms: 10.9 light-years; which means that the light we see now left that star so many years ago.

Even this unit proved unsatisfactory, and a new one has been devised: the parsec. This is the distance from the Earth a star would be that showed a parallax of one second of arc (1″.0). It is equivalent to 3.258 light-years, and is some 18,000,000,000,000 of miles. (*See Note p. 30.*)

This method of direct trigonometrical measurement quickly reached its limit. It has penetrated about as far into space as seems possible. That does not mean that the distances of more stars will not be found by this means, merely that it is doubtful that the parallax of any more distant than the 300-odd now accurately measured can be determined. Further soundings of the depths of space must turn to indirect methods; these are not guesses, but are deductions based on the sure foundations of our present knowledge.

As stated in the previous chapter, the apparent magnitude of a star results from two things, its real or intrinsic brightness and its distance from us. For many investigations a knowledge of the intrinsic brightness is of great importance and the term *absolute magnitude* is used to denote

this. The absolute magnitude of a star is graded by what its apparent magnitude would be at a distance of 10 parsecs. In this grading, the Sun's absolute magnitude would be +4.7; that is, if the Sun were removed to a distance of 10 parsecs, it would appear as a star of about fifth magnitude. "Some stars are known of absolute magnitude brighter than —5, while the faintest at present known has an absolute magnitude of +16.5. This range in brightness represents intensities exceeding the ratio 400,000,000:1."

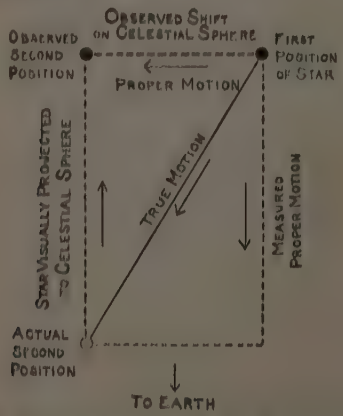
Careful study of certain spectrum lines of many stars has shown that there is close relation between the relative intensity of these lines and the star's absolute magnitude; a relation so close that it is now being used "with marked success as a measure of absolute magnitude." That is, the spectrum of a star indicates how luminous it actually is. When the absolute and the apparent magnitudes are known, it is of course simple to figure the distance of the star. (See *Sizes of the Stars*.)

The great distances of the star clusters and some of the spiral nebulæ are determined also by establishing the relation between the apparent and the absolute magnitudes of certain stars; but in a different way. Some years ago, Miss Leavitt of the Harvard Observatory noted a marked relation between the periods of light variation and the brightness of many Cepheid variables, the pulsating stars described in the previous chapter. The stars with the shorter periods were the fainter, and those with the longer periods the brighter. Careful study of

many photographs, and the actual parallax measurements of some Cepheids, has established the Leavitt-Shapley law that these differences in magnitude are absolute as well as apparent; that is, a Cepheid with a period of five days is actually intrinsically brighter than one with a period of one day, etc. Furthermore it has been possible to make a curve showing the relation of the periods to the absolute magnitudes of all stars of this Cepheid type. If, therefore, Cepheids can be found in the clusters or nebulæ, as has been done by Hubble, the procedure is simple. The period of the star tells us how bright it really is, we compare the light we receive from it with the amount that would reach us if the star were at a known measured distance, and an easy problem in proportion gives the real distance. It is like measuring how much farther away one lamp is than another if both are known to give exactly the same amount of light. The Cepheid variable is our "standard candle."

The Motions of the Stars are determined by actual measurement. The Proper Motions are measured by a micrometer scale that can check minutely any shift of a star on the celestial sphere. An ingenious method is often used to draw attention to the movement. Two photographs of the same section of the sky are made at different times. These photographs are then placed on either side of a partition which comes between the observer's eyes, like that in a stereoscope, so that with his left eye he sees only the left-hand photograph, and with his right eye only the other. The observer then

alternately opens and shuts each eye. If there has been any appreciable shift in the position of a star during the interval between the taking of the pictures, the image of that star will seem to jump back and forth, while the other star images will remain stationary. This is called the "blink" method, and is used in making other comparisons of similar photographic plates. The Radial Motions are revealed by the spectroscope as explained earlier in this chapter. The *Actual Motion* of a star in space is the combination of these two movements, the proper motion and the radial motion, corrected by a proper allowance for the Earth's motion in space, for these observed motions of a star are only relative to the Earth. The diagram shows how the two motions resolve to the true motion in relation to the Earth.



As the Sun is a star, and all of the stars are in motion, the Sun should show a motion of its

own. It does; and this is measurable. If the Sun is moving toward a certain part of the sky, the stars in that part should seem to be moving away from each other, and the stars in the opposite section of the heavens appear to be drawing together, this as a direct result of perspective. The careful investigation of the proper motions of over 5,000 stars shows just this effect, and indicates that the Sun is moving toward the bright star Vega in the constellation Lyra.

The radial motions of the stars should also show a general approach of those in one part of the sky and a general recession of those in the opposite part. They do, and the result is in accord with the proper motion effect.

As a result of the Sun's motion, which is calculated to be at a speed of about 12 miles per second along what is called the Sun's Way, the Earth and the other planets do not move in ellipses *in space*, but in great spirals. (See diagram on p. 159.) This is one of the Earth's motions that must be considered in all calculations of stellar motions.

THE SIZES OF THE STARS. Up to a few years ago, the only information we had secured concerning the sizes of any of the stars was that we were able to obtain from the study of variable stars of the eclipse class. This, of course, excepts the Sun. As the two stars of an eclipsing variable revolve about their common centre of gravity, the spectroscope can ascertain the speed of the orbital motion. From this it is possible to figure the size of the orbit; and the duration of the eclipse, measured for us by the decrease in

light, offers a means to determine the sizes of the two stars.

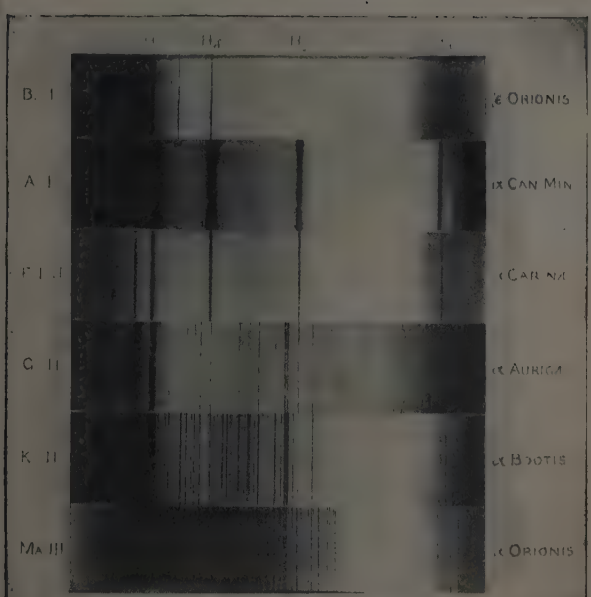
Several theories, however, had suggested that there might be stars of huge dimensions, and three astronomers, using only theoretical considerations, calculated the diameter of the star Betelgeuze. The results were all stupendous. Then, in 1920, Pease of the Mt. Wilson Observatory, with the aid of the great telescope and an "interferometer," designed by Michelson, actually measured the diameter of this same star. His result was "in remarkable accord with the calculated values." The theory of the interferometer and the method of using it are far too complicated to explain here.

The mention of the theoretical calculations of Eddington, Russell and Wilsing, and the proof of their soundness, is made that the reader may see that such calculations, though they may not achieve real accuracy, cannot be dismissed as mere guesses. This is worth remembering in connection with other theories.

Giant and Dwarf Stars. Since the measurement of Betelgeuze, several other stars have been measured by the same method, and the results offer evidence in favor of the general correctness of another theory.

The all-important spectroscope has long since classified the stars according to their condition, and the classes have been assigned letters, M, K, G, F, A, B, and more recently, O. These have been again subdivided.

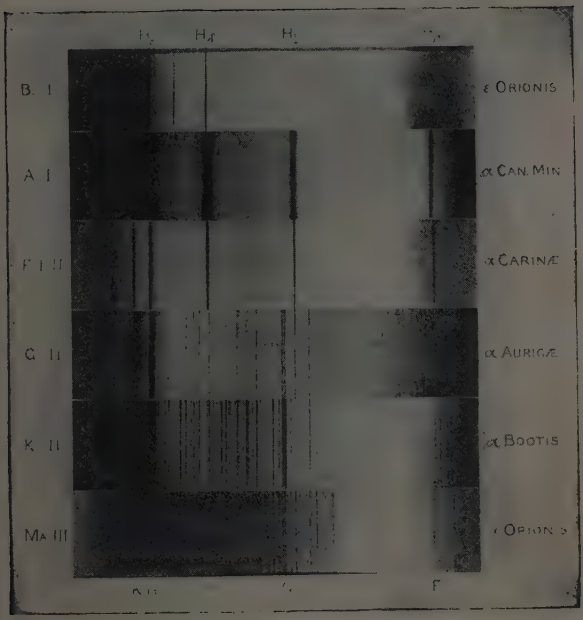
An evolutionary scale was at once suggested, beginning with the hot, and supposedly young



SIX TYPICAL TYPES OF SPECTRA

Note that while they have some lines in common, each type is distinctly different from the others. The Sun belongs to Class G, and its spectrum is nearly similar to that marked α Aurigæ.

From a photograph taken at the Harvard College Observatory



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Note that while they have some lines in common, each type is distinctly different from the others. The Sun belongs to Class G, and its spectrum is nearly similar to that marked α Aurigæ.

From a photograph taken at the Harvard College Observatory

through in the course of its history, and is in accordance with many observed facts." The size and condition of Betelgeuze, Antares and several other measured stars is one of these; they are all giants, all of low density, all of low surface brilliancy and all of spectrum type M.

The spectroscope, then, will tell us that a star is of a certain type, and is either a giant or a dwarf of that type. Will it tell us which of the two? Yes. It was Hertzsprung who first noticed that the whiter stars were all of about the same luminosity, but that the stars of each deeper color divided themselves into two groups, one of high, one of low luminosity. As the spectrum scale was descended from the O, B, to the K, M, types, the differences in the luminosities of the groups increased. That is, while the two yellow star groups differed a thousand times in brightness, the very red star groups differed ten thousand times. Later, he found in the spectra of certain stars that a particular line was more conspicuous for the giants than for the dwarfs. From this Kohlschütter developed a method of determining the absolute magnitude of a star from its spectrum.

It will readily be seen, therefore, that the spectrum of a star can give us a strong indication of its size.

Recent discoveries, notably the facts concerning the Companion to Sirius (which are given in the text accompanying the constellation Canis Major), and Eddington's theory regarding the radiation of mass, will probably cause some modification of Russell's theory; indeed he, him-

self, has proposed a change regarding the principal source of heat of the stars, suggesting internal disintegration of matter rather than increasing density; but the fundamental theory of a giant-dwarf evolutionary scale seems destined to remain for the most part as it is.

Age and Color of the Stars. The foregoing paragraphs show how closely associated age and color are with the sizes of the stars. It is therefore not necessary to devote special space to them here. It may be said, however, that "we seem to require a time-scale which will allow at least 10,000,000,000 years for the age of the Sun" (Eddington), and the Sun is placed somewhat more than half-way down the scale of dwarf stars.

Mass of the Stars. For any direct knowledge of the masses of stars, we must turn again to the close double stars, the binaries that revolve together about a common centre of gravity. If we can measure the distance of the system from us, we can find the mass of the two stars; for the spectroscope will measure for us the speed and direction of the stars' motions in their orbit, and we can plot the orbit and measure its size by applying the law of gravitation, which is just as much in control of the motions of the stars as it is of the planets in the solar system.

Having found the combined mass of the two stars, it is often possible, by noting the amount of motion each one makes, to divide the combined mass properly and to assign each component of the double its correct amount. The

Earth-Moon system revolves about a common centre of gravity, as do all revolving bodies, but owing to the much greater mass of the Earth the gravitational center is far closer to the center of the Earth than to the center of the Moon; in fact it is in this case below the surface of the Earth. The Earth's motion, then, is a sort of eccentric turning about this point, while that of the Moon is a wide-swung ellipse. A distant observer measuring these motions and their time could, with the aid of the law of gravitation, find the combined mass of the system and assign to the Earth and Moon each its proper share of that mass. This is just what we do in the case of a double star system.

From all the data as yet gathered, we find that there is a great similarity between the masses of the stars. We have yet to discover one with as little as one-tenth the mass of the Sun, and those with as much as twenty times the mass are scarce, though a few have been found with masses running up to somewhat over fifty times. Some few years ago, Eddington published calculations showing that a star only one-tenth the mass of the Sun could never become luminous, and that one whose mass was 100 times that of the Sun either could not form at all or would blow itself to pieces by its own radiating energy.

The similarity in the mass of the stars is so close that it is possible to reverse the double star problem, and, by assuming the mass of a double star to be equal to the *average*, to calculate the distance of the system. "Distances derived in this way are very reliable."

Eddington has also recently demonstrated that there is a very close relation between the luminosity (the absolute magnitude, not the apparent) of a star and its mass. He has covered a wide range of magnitudes, and the comparison of his "curve," which was drawn from theory, with the known absolute magnitudes and masses of stars shows a remarkably small variation. It is therefore possible to calculate the mass of a star from its luminosity.

It may interest the reader to know that the Einstein Theory of Relativity limits the mass of a star in a different way. According to the theory, matter curves space, and if too much matter were accumulated in one body (for instance, a globe of water 400,000,000 miles in diameter, which is the measured size of the star Antares), it would curve space so much that it would *close it up* around itself and there would be no space left for anything else, and the globe *couldn't* be bigger!

Temperatures of the Stars. Until recent years, it was possible only to estimate stellar temperatures. The temperature of the Sun could be measured, and with this as a basis, together with the obviously sound deduction that, in the spectral series, the blue-white B stars must be hotter than the yellow G, and the G hotter than the dull red M stars, reasonably accurate calculations could be made. Since the improvements in instruments, the temperatures of "More than a hundred stars (124 to be exact), including some of almost every known variety, have been measured. . . . With the perfected equipment, radiation which sufficed to heat the

receiver by less than 100,000th part of a degree has been measured, and any star which can be seen with the naked eye is within the reach of the apparatus."—(Russell). The stellar temperatures range from about 3,000 degrees for the M type stars to about 22,000 degrees for the O type.

These temperatures are, of course, *surface* temperatures; for we can receive only the heat and light that escapes from the star by radiation from the surface. The internal temperatures must rise to the millions of degrees. In fact, basing his calculations on the necessity for an expansive force (and hence heat) in the inner portions of a star to offset the pressure of the outer portions, Eddington shows that the temperature at the centre of the average star must be about 40,000,000 degrees. He says in part: "Do not think that 40,000,000 degrees is heat so extreme that temperature has become meaningless. These stellar temperatures are to be taken quite literally." Temperature is merely a way of expressing how fast the atoms and molecules of a substance are moving. "For example, at the temperature of this room, the molecules of air are rushing about with an average speed of 500 yards a second; if we heated it to 40,000,000 degrees, the speed would be just over 100 miles per second. . . . For an astronomer this is the most ordinary degree of speed. . . . The experimental physicist is quite contemptuous of it, for he is used to handling atoms shot off from radium and similar substances with speeds of 10,000 miles a second."

HOW TO USE THIS BOOK

The study of the constellations should be taken up by Seasons in the order in which they appear in the table of contents.

By following out the order indicated the student will in a few nights of observation be able to identify the various configurations that comprise the constellations conveniently situated for study in that time of year.

A large plate, showing the appearance of the heavens at a designated time, on the first day of the quarter months, is inserted before the diagrams of the constellations selected for study in the respective seasons. This plate should be consulted before beginning the study of the heavens, in order to obtain a comprehensive idea of the relative positions of the constellations.

A knowledge of one constellation enables the student to determine the position of the next in order. In this work, the identification of each constellation depends on a knowledge of constellations that precede it in the order given, always bearing in mind that each season is distinct and separate from the other seasons, which enables the student to begin his study of the constellations at any time of the year.

The Apparent Motions of the Stars

It may be that the student desires to proceed in this conquest of the sky at a more rapid pace than the scheme of study permits. To assist such, it should be borne in mind that the circumpolar constellations, as Ursa Major, Ursa Minor, Draco, Cepheus, and Cassiopeia are called, are visible in our latitude in the northern sky every night.

A reference to their diagrams, and a glance at any of the large plates showing the entire group in their respective positions, will suffice for the student to identify them.

The hours of darkness alone limit the speed with which a knowledge of the constellations can be acquired.

Let us suppose that the student begins his search for the constellations on the night of April 1st, at nine P.M. He has for his guide the large plate, and the spring group of eleven constellations set forth in the diagrams. The remaining three constellations of the circumpolar group are, as we have seen before, visible in the north.

If he faces the western sky, he will see Orion just setting, and the brilliant Sirius in Canis Major hanging low. Farther to the northwest, ruddy Aldebaran drives down before him the Hyades swarm in Taurus, and the Pleiades sink beside them. Perseus swings slowly northward to disappear at midnight for a short period behind the northern horizon.

In the southeast, Virgo may be seen, and in

the east, well up, blazes mighty Arcturus, the gem of Boötes, below which the circlet of the Northern crown leads upward the diamond head of Serpens and Hercules, just rising.

These and the Spring group of twelve constellations set forth in the diagrams complete the list of wonders visible at this precise time, but the stars apparently are never still, and doubtless, while the student has been passing from one constellation to another in the western and southern skies, others have been rising in the east and northeast.

At eleven P.M. the Lyre is up, and Ophiuchus and Libra can be discerned. At one A.M. Scorpio in the southwest and Cygnus in the northeast are ready to claim the attention. By two A.M., Aquila, Delphinus, and Sagittarius are rising, and at break of day Andromeda, Pegasus, and Capricornus are appearing.

In no way can the seeming movement of the stars be better understood than by actual observation. The observer must bear in mind that the movement is an apparent one, that it is the earth that is moving and not the stars. He has only to think of the analogy of the moving train beside the one that is standing still, and the true state of affairs will at once be evident.

To appreciate further this apparent change in the situation of the constellations, the student should refer to the large plates successively. In each successive one he will note the advancement westward of the constellations mentioned above, rising in the east late at night.

The student can best get an idea of this west-

ward apparent movement of the stars by noting the position of some bright first-magnitude star from night to night. He will soon be able to calculate the position of this star a month or more ahead, and this calculation applies to all the constellations and stars.

The Diagrams for Constellation Study

The diagrams of the constellations face the text, and depict in each case their appearance in the sky in mid-season.

To facilitate locating and observing the constellations, the student should face in the direction indicated after the title of each constellation.

The four large plates are so arranged that the observer is supposed to be facing south, with the diagram *held overhead*. By turning the book around in quarter turns, the eastern, northern, and western skies are shown successively.

On many of the diagrams the positions of star clusters are indicated. These are designated by the initial letter of the astronomer who catalogued them, as, for instance, 8 M. signifies star cluster number 8 in Messier's catalogue. In some cases numbers alone are used; these refer to the numbers in Sir John Herschel's catalogue.

Stellar Magnitudes

One other matter is essential in beginning the study of the constellations. It is highly important to be able to judge stellar magnitudes. Remember, magnitude, as it relates to the stars,

refers to luminosity, not mass; in other words, solely to the brightness of the stars as they appear to us, their *apparent*, but not their *real* brightness. A faint star may be far brighter than one that appears bright to us, for the reason that its light is diminished by the distance it is away from us.

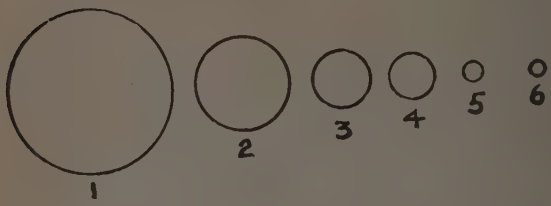
Face North on a clear and moonless night, being careful to exclude all artificial light from the eyes. Locate Polaris, and then trace out the six other stars in the Little Dipper, using the Diagram for the constellation Ursa Minor if necessary.

Here you will find stars of all the magnitudes visible to the naked eye except the first and sixth magnitude. Sixth magnitude stars are at the extreme limit of visibility for the naked eye. First magnitude stars are the brightest stars, and a standard first magnitude star is 2.5 times brighter than Polaris. The stars Aldebaran (in Taurus) and Altair (in Aquila) are good examples of first magnitude stars.

The figures expressing the magnitudes of the stars appear above the dots representing the stars on the Diagrams.

Polaris, the star that was used in measuring the light of all the stars, is a standard second magnitude star. Compare the light of Polaris with that of the star γ Ursæ Minoris, which is of the third magnitude, by glancing back and forth from one star to the other. Polaris is 2.5 times brighter than gamma. Then compare in like manner the stars gamma and zeta, which is of

the fourth magnitude, and so on, always bearing in mind that the ratio of difference in luminosity between successive magnitudes is 2.5.



Stellar Magnitudes.

A star appears 2.5 times as bright as one a magnitude fainter in the scale.

In a short time the eye becomes trained to observe slight differences in the light of the stars, and you will be able to judge accurately the magnitude of any star in the sky.

The magnitudes assigned to the stars in the diagrams are derived from the Harvard Photometry. When a star is midway between two magnitudes the numeral is underlined, thus, $\underline{2}$ indicates a 2.5 magnitude star. The stars in neighboring constellations are represented by circles.

The Greek letter names of the prominent stars in the constellations are placed, in each case, below the dots representing the stars. In referring to stars, it is the practice to use the genitive case of the constellation; thus, the star Capella, which is alpha in the constellation Auriga, is called alpha Aurigæ.

A table in the Appendix gives the Greek alphabet, and the genitive case for all the constellations.

The Diagrams for the Telescopist

The diagrams represent the appearance of the constellations in the season in which they are placed, and favorable location for observation was chiefly considered in thus grouping them. The student can vary the arrangement to suit his convenience.

The so-called "circumpolar constellations" (i.e. those that never sink below the horizon) are of course available for observation at any time of the year, and the student can choose his own time for studying them.

Only the constellations visible in the latitude of the New England and Middle States have been included in this book.

The author presupposes that the telescope to be used in connection with this book is not equipped with circles, otherwise recourse should be had to some such book as Webb's *Celestial Objects for Common Telescopes*, for a more exact location of the objects of interest, in terms of Right Ascension and Declination.

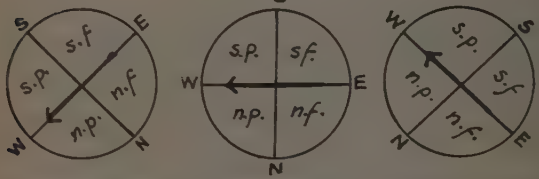
For the most part only double stars with a primary of the sixth magnitude or brighter are given, as it is difficult to direct the telescope at a star of lesser magnitude unless its position is accurately known.

In searching for double stars many faint yet beautiful pairs and triples are observed, so that

it is well to have such a book as Webb's, in order that these objects can be identified.

The diagrams include over three hundred double stars, and many fine clusters and nebulæ.

Considerable discrepancy will be noted in the colors assigned to the double stars, and those observed. The coloring in many cases is at best elusive, and atmospheric conditions and peculiarities of vision play an important part in determining it. In a number of cases the colors are very pronounced and render the object of surpassing beauty, as for instance in the great favorite β Cygni. The first color given is that of the primary or brightest star, the second color given is that of the companion.



Star east, rising Star south Star west, setting

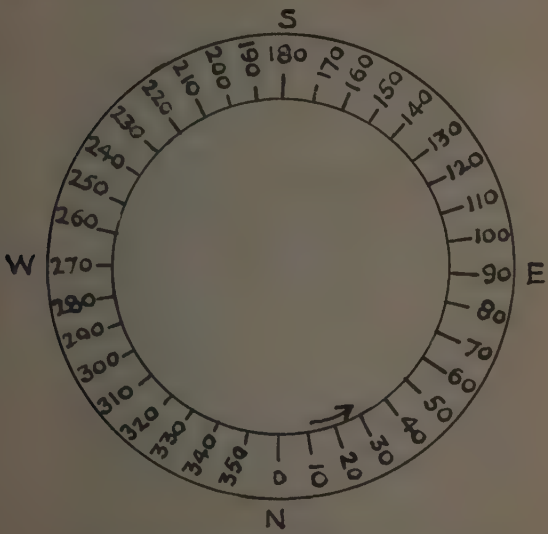
n. p. north preceding.
n. f. north following.
s. p. south preceding.
s. f. south following.

Arrow indicates direction of star's motion across the field.

The field of view in the ocular or eye-piece of the telescope, is divided into quadrants. The accompanying diagram indicates their designations, and also shows the direction of the motion of the stars across the field of view, and the

cardinal points of the field. In referring to the position of an object in the field, it is customary to use the initial letters in the quadrant where the object appears.

The position angle measures the inclination to the meridian of a line drawn through the double stars. It shows the observer where to look for



Position of Angle of a Double Star.
Showing the double star beta Cygni; position angle 55 degrees.

the companion star, and is reckoned from 0 degrees to 360 degrees, beginning at the north point, and proceeding through the east, south, and west to the north. The student should bear in mind in this connection that in the telescope the north and south points are reversed.

Decimals are omitted from the distances given between the doubles, as, in the wider doubles, as most of those referred to in the text would be termed, absolute accuracy in measurements (which are from centre to centre, and in seconds of arc), is non-essential for purposes of observation purely.

A three-inch glass should split stars that are distant from each other 2.3″. Of course this question of splitting doubles depends in a great measure on the power of the eyepiece used, the condition of the atmosphere, and the quality of the telescope and the eyesight of the observer. Serviss recommends a power of from fifty to seventy to the inch of aperture. The author has succeeded in seeing the great majority of the doubles mentioned in the text with a power of 130. The diagram shows graphically the differences between naked eye, field glass and telescope. See also curve showing the theoretical limits of the "seeing power" of telescopes of various apertures on p. 438.

The following symbols are used in the diagrams:

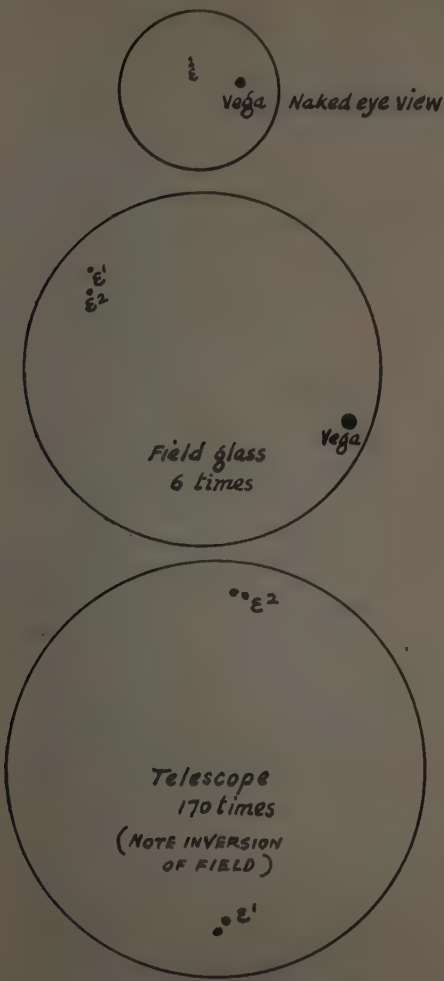
○ To indicate the double stars.

+ To indicate the position of the nebulæ.

● To show the location of the star clusters.

The following abbreviations appear in the text:

A., Angle; D., Distance; H., Herschel; Mg., Magnitude; M., Messier; Σ, Wm. Struve; OΣΣ, Poulkova Catalogue, Part II; P., Piazzi Smyth; OΣ, Otto Struve.



The Double-double Epsilon Lyræ

A Scale of Celestial Measurements

It is of great importance and convenience to be familiar at the outset with a scale of celestial measurements, knowledge easy to acquire.

All through this book, and other guides to the constellations, there are made, in indicating the constellations, individual stars, and objects of interest, references to the *number of degrees* that separate them from other stars. It is, therefore, essential to have an idea of these distances as measured in degrees on the celestial sphere.

The accompanying diagram will afford the reader a standard scale.

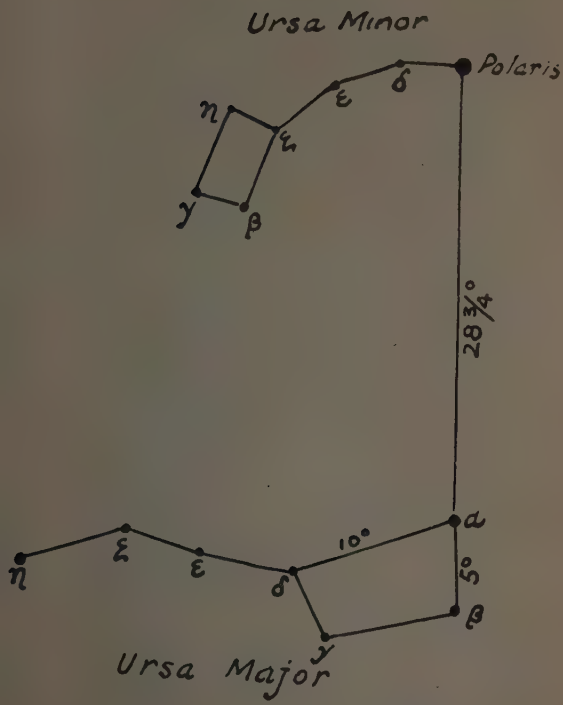
Face north and observe "The Dipper," (See also p. 80.) in the constellation of Ursa Major. The Pointer stars, alpha and beta Ursæ Majoris, are five degrees apart, and always point to the Pole Star twenty-eight and three-fourths degrees distant. From alpha to delta Ursæ Majoris is ten degrees.

If these distances and measures are borne in mind as you pursue the study of the constellations, the directions given for locating the stars will be more easily understood, and you will be able to measure other distances.

The diameter of the full Moon is just about one-half a degree.

This information is of prime importance in describing the location of a meteor, or if the reader should be fortunate enough to discover a Nova or Comet.

Many novæ have been discovered by amateurs with the naked eye. Nova Aurigæ and Nova



α to . Ursæ Majoris	=	5	degrees.
α to δ " "	=	10	"
α Ursæ Majoris to Polaris	=	28¾	"
α to γ Aquilæ	=	2	"
α to . Canis Minoris	=	4	"

The degrees are those of a "great circle."

Persei were both discovered by Dr. Anderson of Scotland. Dr. Anderson made it a practice to observe the heavens every fair night before retiring. His patience and persistence were rewarded by the discovery of several new stars.

In concluding this chapter, it is suggested that it will be worth while for the naked eye and field glass observer to read the text accompanying the telescopic diagrams, and for the telescopist to read the naked eye and field glass text. Many items of interest to both are included in one text and are not repeated in the other.

THE CONSTELLATIONS

THE "BIG DIPPER" AND THE NORTH STAR

The first step in observational astronomy is the location of the Pole Star, named from its position "Polaris," about which, as a wheel about a hub, the heavens seem to turn; this, because it marks the place toward which the axis of the Earth points.

If you do not know where North is, a compass will direct you. Lacking that, face the direction of the setting sun, make a quarter turn to the right, and you will be looking northward. You should then have no difficulty in identifying the seven bright stars that form the well known "Big Dipper."

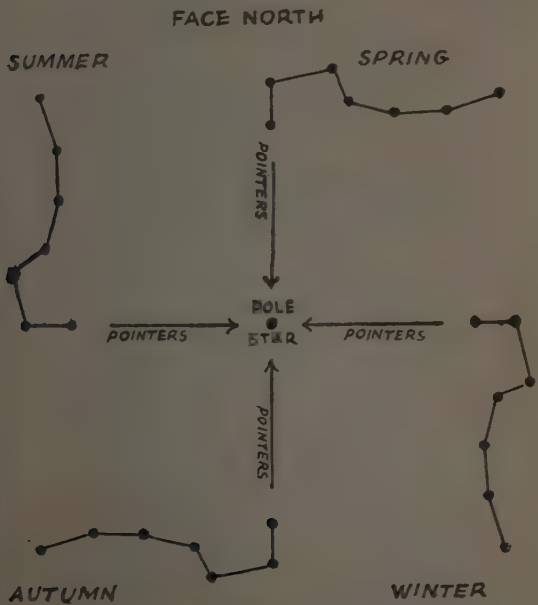
The diagram on the opposite page shows this figure. (See also p. 77.)

You will note that a line drawn through the two stars forming the side of the "bowl" farthest from the "handle" of the dipper point toward another bright star. This is Polaris.

The Dipper is the conspicuous part of the constellation Ursa Major, the Great Bear, and from the latitude of New York, and higher latitudes, never sets. It is visible each clear night throughout the year.

It is well to note that the elevation or "height" of Polaris above the horizon is always equal to the latitude of the observer. At the North Pole

of the Earth, latitude 90, Polaris would be directly overhead; at the equator, latitude 0, it would be on the horizon. A moment's consideration will show the simple reason for this. South of the equator, Polaris of course cannot be seen; it never rises.



The positions assumed by the Dipper in the early evening each season.

N.
E.
W.
S.
Vega in LYRA
Solstitial Colure
CEPHEUS
CASSIOPEIA
ANDROMEDA
TRIANGULUM
Pleiades
Algol
PERSEUS
HERCULES
SERPENS
CORONA BOREALIS
DRACO
URSA MINOR
Polaris
North Pole
TAURUS
Hyades
Aldebaran
Capella
The Kids
Nath
AURIGA
ERIDANUS
Bellatrix
Betelgeuze
ORION
Rigel
LEPUS
BOÖTES
Arcturus
The Pointers
Cor Caroli in CANES VENATICI
Equinoctial Colure
URSA MAJOR
LYNX
Over Head
ECLIPTIC
Castor
GEMINI
Pollux
VIRGO
Spica
COMA BERENICES
LEO MINOR
LEO
Denebola
The Sickle
Regulus
Bee Hive
CANCER
Procyon
CANIS MINOR
MONOCEROS
Sirius
CANIS MAJOR
Algorab
CORVUS
Equator
HYDRA
The Heart of Hydra
Alphard
CRATER
ARGO NAVIS
Naos

THE CONSTELLATIONS OF SPRING

The folded map opposite shows the principal stars visible from Latitude 40° N. at:

9:00 P.M. April 1st

9:30 March 22	8:30 April 7
10:00 March 14	8:00 April 14
10:30 March 7	7:30 April 22

The Times are Eastern Standard.

Chart held in this position depicts Southern sky. Quarter turns of the book from left to right give correct views successively of Eastern, Northern and Western sky.

URSA MAJOR

URSA MAJOR (er′-sa ma′-jor)—THE GREAT BEAR
(Face North)

(Location: This is given on page 80.)

Mythology

He who would scan the figured skies
Its brightest gems to tell,
Must first direct the mind's eye north,
And learn the Bear's stars well.

The Chaldeans, and the Iroquois Indians of our own land, both knew this constellation as "the Great Bear." By no stretch of the imagination can the figure of a bear be traced out of the stars in this region, and it is one of the great mysteries as to how the constellation came to be so named.

There can be no question as to the great antiquity of the constellation Ursa Major, for it is a conspicuous star group and must have attracted universal attention at a very early date in history.

There are a great many fascinating legends relating to this constellation contributed by the people of all lands from the earliest times. Only a brief reference to them can be made here.

According to a very ancient legend the Bear represented Callisto, the daughter of Lycaon,

King of Arcadia. She was beloved by Jupiter who changed her into a bear to protect her from Juno's wrath. Before Jupiter had effected this change, Callisto was almost killed inadvertently by her little son Arcas, who, seeing the bear and not knowing it was his mother, was about to kill the creature. To avert this disaster Jupiter transferred Arcas and Callisto to the skies, changing Arcas into a little bear and placing him in the heavens near his mother.

In England, "the Dipper" is called "the Plough" or "Charles's Wain."

For the Naked Eye and Field Glass

The stars α and β Ursæ Majoris in "the Dipper" are called "the Pointer Stars," as they invariably point to the Pole Star, 28¾° from alpha.

ϵ Ursæ Majoris is very nearly opposite alpha Cassiopeiæ, and these two stars are at an equal distance from the Pole.

The star o Ursæ Majoris marks the tip of the Bear's nose. A clearly defined semicircle of faint stars begins at omicron Ursæ Majoris, and ends in the pair ι and κ Ursæ Majoris that mark the Bear's right forepaw. This group resembles a sickle.

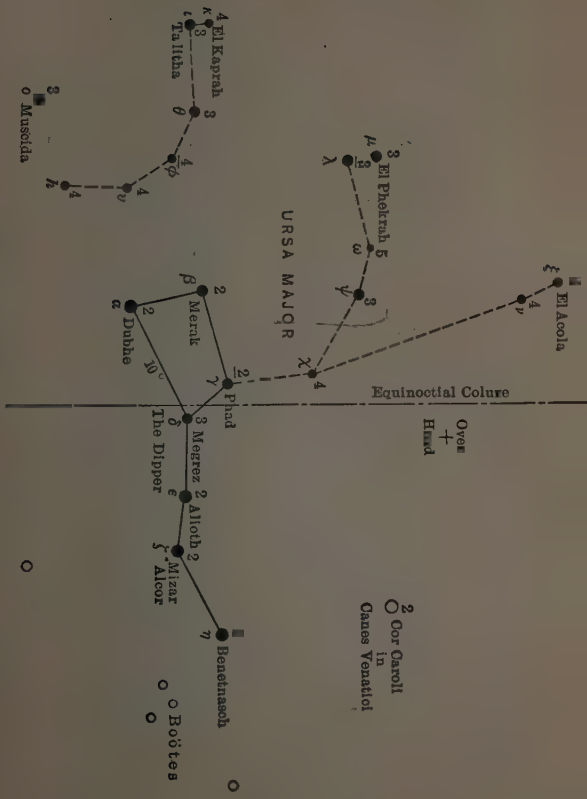
Note the little star Alcor, close to Mizar. The Arabs called these stars "the Horse and the Rider," and the star Alcor was regarded by them as a test of good eyesight. There is an attractive grouping of stars near for an opera or field glass.

The entire figure of the Great Bear circles about the Pole once in twenty-four hours. This is, of course, an apparent motion due to the rotation of the earth. A line connecting the "Pointer Stars" with Polaris may be regarded as the hour hand of a clock. With a little practice the time of night can be ascertained to an approximate degree by observing the position of this stellar hour hand.

When we see the "Big Dipper" high in the sky in the early evenings in May, it is over Canada. When it is near the horizon it is over Siberia, and we are looking at it across the North Pole.

In the early evening hours in the Spring, the "Dipper" will be seen high in the northern sky above the Pole. In Summer, it is to the left or west of Polaris. In the Fall look for it close to the horizon below the Pole, and in the Winter it will be found to the right or east of the Pole Star. (See diagram, p. 81.)

URSA MAJOR



El Kaprah
Ta litha
Muscida
El Phekrah
URSA MAJOR
El Acola
Merak
Dubhe
Phad
Equinoctial Colure
Over Head
Megrez
The Dipper
Alioth
Mizar
Alcor
Benetnasch
Cor Caroli in Canes Venatici
Boötes

For the Telescope

"This familiar constellation offers a large field to the persevering observer."

Double Star	*Magnitude*	*Distance Seconds*	*Angle Degrees*	*Remarks*
ζ	2–4	14	147.6	Both white. Alcor in same field. View in opera-glass.
23	3.8–9	23	272	Fine color contrast.
σ^2	5–8	4	263	
57	5.2–8.2	5	10.7	
Σ 1415	6–7	16	167	
Σ 1561	6–8	10	266	
Σ 1495	6–8.3	34	38	
Σ 1520	6.5–7.8	13	345	
65	6–8.3	3	36.5	

Note the two fine nebulæ, 1949 and 1950, separated by only half a degree. 2843 (M 97) is a large planetary nebula called "the Owl Nebula." South of the Spiral Nebula, 3572, is the second magnitude star Cor Caroli, a beautiful and easy double for a small telescope.

ζ is probably the best known double star in the heavens, and one of the most beautiful. It was the first double star discovered. This discovery was made by Riccioli in 1850. In 1889 Professor E. C. Pickering discovered that the star was also a close binary. Its period is 20 days and 13 hours. The mean distance between the two components is about 19 million miles. The star is 72 light years distant, and has the distinction of being the first star daguerreotyped by Bond.

(*Continued on page 90.*)

URSA MAJOR

Spiral Neb.
3572
Cor Caroli
Σ 1561
Σ 1495
Σ 1520
2843
Σ 1415
1949
1950
23
57

For the Telescope—*Continued*

γ lies in a particularly attractive field.

The stars β, γ, δ, ϵ and ζ, all in the "Dipper," together with a few other stars in the neighborhood, form a closely related system. These stars are from 90 to 100 light years distant. They are all moving in the same direction, and at the same rate of speed, like a flock of geese flying across the heavens. There are several bright stars that are considered a part of this group of stars, although they appear to be far distant from them in the sky. These stars are β Aurigæ, alpha Coronæ, and Sirius. The point from which the motions of all these stars appear to be directed is on the borders of Ursa Major, and is pointed out by a line from θ through κ Ursæ Majoris, carried as far again.

Of the seven stars in "the Dipper," five, as noted above, are moving in the same direction. Alpha and η Ursæ Majoris are, however, moving in an opposite direction, both receding at the same rate from a point in the sky not far from Vega in Lyra. The contrary motions of these stars in "the Dipper" will, in the course of thousands of years, greatly distort the familiar figure we now know as "the Dipper" so as to render it unrecognizable. At the rate of speed these stars are moving, it would take, according to Professor Russell, 150,000 years for them to traverse five degrees, that is, the distance between "the Pointer Stars." These stars, according to Dr. Ludendorff, are all receding from a common "radiant point" which lies about half way between κ Ursæ Majoris and Pollux in Gemini. They are approaching our system at rates varying in velocity from seven to ten miles a second.

URSA MINOR

URSA MINOR (er′-sa mi′-nor)—THE LITTLE BEAR
(Face North)

LOCATION.—The two "Pointer Stars," alpha and beta Ursæ Majoris, indicate the position of Polaris, the North Star, alpha Ursæ Minoris. This famous star marks the tip of the tail of the Little Bear, and the end of the handle of "the Little Dipper."

Mythology

On thy unalterable blaze
The half-wrecked mariner, his compass lost,
Fixes his steady gaze,
And steers, undoubtingly, to the friendly coast.

You will read in the mythological references to the constellation Ursa Major, the legend which connects that constellation with Ursa Minor.

There is a beautiful Indian legend relating to the Little Bear. A hunting party of Indians had lost their way in the forest, and prayed to their gods to point out to them the homeward path. In answer to their prayer a little girl appeared, who informed them that she was the spirit of the Pole Star and had been sent to guide them. They followed her and soon reached home in safety. Ever after they called the Pole Star "the Star which never moves." At their death the hunters were transported to the sky and forever follow the faithful Pole Star.

For the Naked Eye and Field Glass

Polaris, contrary to general belief, is not located at the exact Pole of the Heavens, which is the extension of the earth's axis on the celestial sphere. As a matter of fact, the Pole Star is 1¼° from the true Pole. Polaris is a standard second magnitude star, and its light has been compared with all the other lucid stars, and thousands of stars invisible to the naked eye, in order to derive their magnitude.

Polaris is a star of the solar type. It is 470 light years distant and 2500 times as bright as the sun. It is approaching our system at the rate of 15 miles a second. It revolves around the Pole once in 24 hours in a circle 2½° in diameter. Within this circle 200 stars have been photographed.

The North Star is always as many degrees above the horizon as the observer is north of the Equator. If you were at the North Pole, Polaris would shine directly overhead. If you stood on the Equator, Polaris would be on the horizon.

Polaris is a triple system of suns, as it is a spectroscopic binary with a period of 3.97 days, and has in addition a ninth magnitude companion.

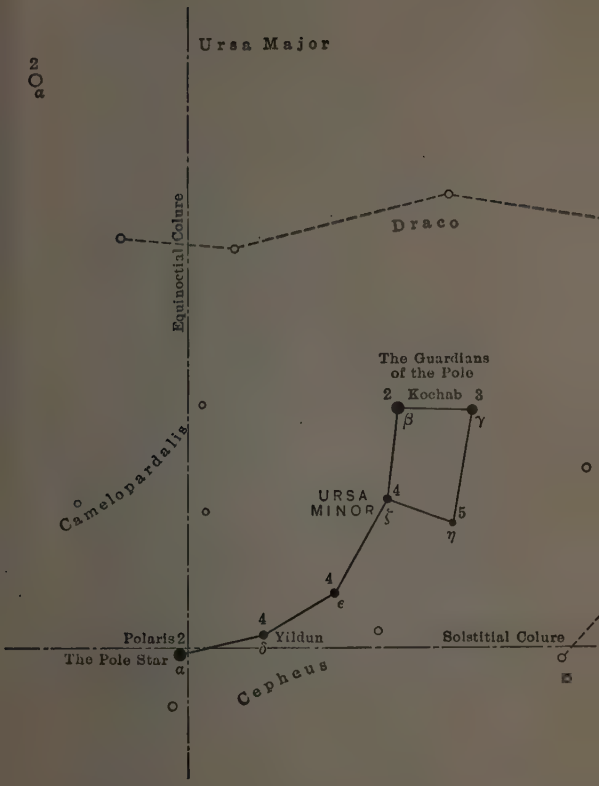
Compare the light of the different stars in Ursa Minor as a means of estimating stellar magnitude.

The stars γ and β Ursæ Minoris are called "the Guardians of the Pole."

Owing to the Precession of the Equinoxes, the position of the true Pole is continually but slowly changing, following a circle around the Pole of the Ecliptic, which lies in the constellation Draco.

It takes the North Pole about 26,000 years to complete its great circle. About the year 7500 A.D. the star alpha Cephei will be the North Star. In 13,500 A.D. Vega will be the Polaris of the sky, and about the year 21,000 A.D. alpha Draconis will again be the North Star. (See diagram p. 36.)

URSA MINOR


Ursa Major
2
α
Equinoctial Colure
Draco
The Guardians
of the Pole
2 Kochab 3
β
γ
Camelopardalis
URSA
MINOR
4
ζ
5
η
4
ε
4
δ
Yildun
Polaris 2
The Pole Star
α
Solstitial Colure
Cepheus

For the Telescope

The following double stars in this region of the sky are a few of the many that await observation.

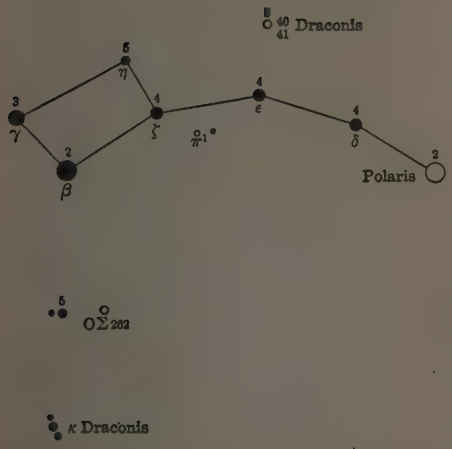
Double Star	*Magnitude*	*Distance, Seconds*	*Angle Degrees*	*Remarks*
α	2–9	18	210	Yellowish–White–Blue.
π^1	6–7	30	83	Both yellow.
40–41	5–6	20	235	In Draco. A fine double.
ΘΣ 262	7.3–8.2	28	182	

If you have a three-inch telescope, and good atmospheric conditions, you should be able to see the companion to Polaris, but it is not an easy object.

If you have difficulty in seeing faint companion stars, try the method of averted vision, or gazing intently at a distant part of the field of the ocular. This method brings into use the more sensitive parts of the retina and succeeds where direct vision often fails.

For locating this little blue companion of the North Star the following facts may be of service. During the early evenings of October, November, and December, the companion is below Polaris. During April, May and June it is above. It is to the left of the North Star in July, August and September, and to the right in January, February and March.

URSA MINOR



GEMINI

GEMINI (jem′-i-ni)—THE TWINS (Face West)

LOCATION.—A line drawn from β to κ Ursæ Majoris, prolonged an equal distance, ends near the bright star Castor, alpha Geminorum.

Mythology

> Tender Gemini in strict embrace
> Stand clos'd and smiling in each other's face.
>
> MANILIUS.

The two bright stars Castor and Pollux have been known as "the Twins" from the earliest times. The Arabs regarded them as "Two Peacocks," the Egyptians "two Sprouting Plants," and the Hindus "twin Deities."

Since classic times the constellation has figured as the Twin youths, Castor and Pollux.

There is a wealth of myth and legend relating to the Twins.

Mythology links the Twins with the adventurous band, known as "the Argonauts," that sailed with Jason to secure the Golden Fleece.

Castor and Pollux were said to be the sons of Jupiter and Leda. Castor excelled in the management of horses, while Pollux was famous as a soldier and pugilist.

When the Roman soldiers charged the foe in battle, they thought that Castor and Pollux led them on to victory.

The twins were great favorites with mariners who sailed the seas in ancient times. In honor of them the electrical effect known as "St. Elmo's Lamps," that dart about in the rigging of ships in a storm, were known as "Ledean Lights."

Macaulay celebrates the Twins in his famous poem, "The Battle of Lake Regillus."

There is a record of a lunar occultation in Gemini that was observed about the middle of the fourth century B.C.

For the Naked Eye and Field Glass

The constellation is characterized by two nearly parallel rows of stars, the northern extending in the direction of Taurus, the southern towards Orion.

An isosceles triangle is formed by the stars Castor in Gemini, Aldebaran in Taurus, and Capella in Auriga.

The point where the ecliptic crosses the solstitial colure (see Diagram) is the spot where the sun appears to be when it is farthest north, about June 21st of each year.

At the point indicated on the Diagram near the star θ Geminorum, a new star was discovered by Enebo, March 12th, 1912. It attained a maximum brilliance of about 3.5 magnitude, and is now a faint star below the eleventh magnitude.

From December 10th to 12th meteors may be observed near the head of the Twins, marked by the stars Castor and Pollux. These meteors are swift in their movements, and leave short trails.

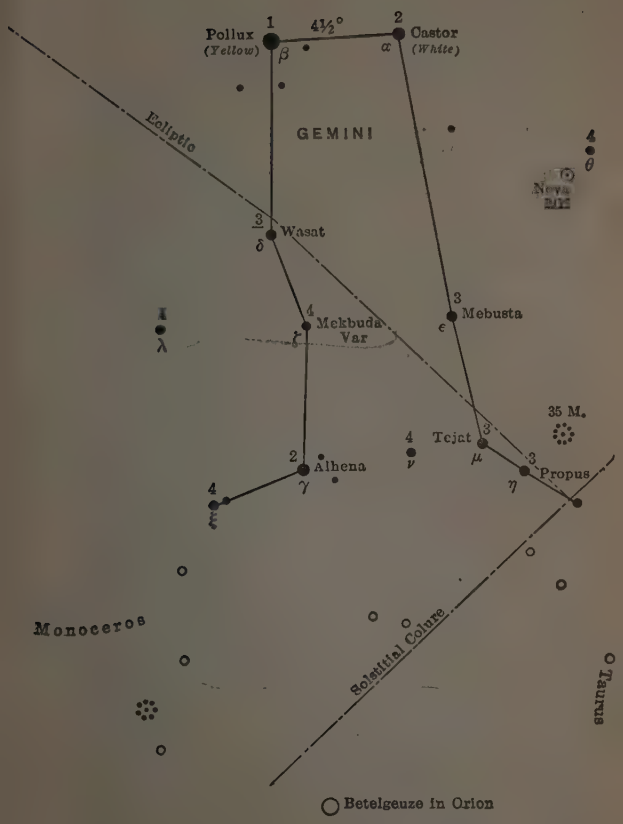
From October 18th to the 20th there is a meteoric shower radiating from the feet of the Twins.

Gemini is well placed for observation in the early evening, about January 1st in the east and about June 1st in the western sky.

Those equipped with opera or field glasses will be able to locate the star cluster M35. Two wonderful streams of little stars run parallel northwest on each side of the cluster.

The star η Geminorum is historically interesting. It was near this star that Sir William Herschel, in 1781, observed the object which he found to be an unknown planet, the planet subsequently known as "Uranus."

GEMINI


Pollux
(Yellow)
β
1
4½°
2
Castor
(White)
α
GEMINI
Ecliptic
4
θ
Nova
1912
3
Wasat
δ
4
Mekbuda
Var
ζ
3
Mebusta
ε
I
λ
35 M.
4
ν
Tejat
3
μ
2
Alhena
γ
3
Propus
η
4
ξ
Monoceros
Solstitial Colure
Taurus
Betelgeuze in Orion

For the Telescope

The constellation Gemini is a rich field for the telescopist. Webb notes over 50 double stars, only a few of which can be cited here.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	2–3	6	225	Both greenish white. Binary. A beautiful object.
ζ	3–7	94	350	Yellow–Blue. Primary Variable.
15	6–8	33	205	White–Blue.
38	5.4–7.7	5	174	Yellow – Blue. Fine contrast.
δ	3.7–8	7	210	Yellow–Red or purple.
ε	3.9–5	110	94	
ν	4–8	113	330	
20	6–7	20	209	
λ	3.5–10	10	30	Greenish–Blue. Difficult for 3 in. glass.
κ	3.7–8	6	235	Orange–Pale blue.

The stars π and μ both have 11th magnitude companions distant 22″ and 73″ respectively.

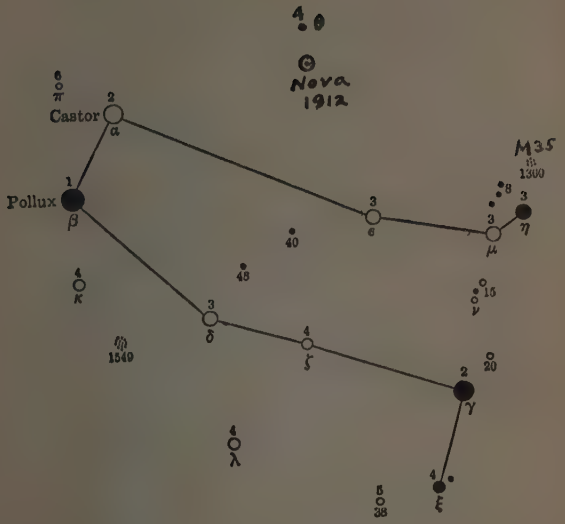
γ has a remarkable array of stars near it, and there is a rich field in the region around the star η Geminorum.

Herschel regarded Castor as the largest and finest of all double stars in our hemisphere. It was observed to be double by Bradley in 1750. The two components make a complete revolution in a period exceeding 300 years. It was the first *binary* star discovered, a fact ascertained in 1803. The star has a spectrum of the Sirian type. Castor has a third attendant, a faint star, 73″ distant, with a period probably exceeding 10,000 years. It has now been determined that the three components of Castor are spectroscopic binaries, so that the system really consists of six stars.

Castor has a proper motion of 8 miles a second, and is 43 light years distant.

(Continued on page 102.)

GEMINI



For the Telescope—*Continued*

Pollux is 32 light years distant, has a proper motion of 18 miles per second, and is receding from our system at the rate of 1.9 miles a second. It is a multiple star having at least 6 components, most of which are very faint.

A few centuries ago Castor was brighter than Pollux, which now exceeds it in brilliance. One of these stars is, apparently, slowly changing in brightness, but thus far we have been unable to determine which star is variable.

The cluster 1360 (M 35) is one of the finest clusters in the heavens. A marvellously beautiful object. No one can observe it for the first time without an exclamation of wonder and delight.

AURIGA

AURIGA (â-ri'-ga)—THE CHARIOTEER
(Face Northwest)

LOCATION.—A line drawn from delta to alpha Ursæ Majoris, and prolonged about 45 degrees, ends near the brilliant first magnitude star Capella, in the constellation Auriga. The star is unmistakable, having no rival in brightness near it.

Mythology

The constellation of Auriga is extremely ancient. According to the Greek legend the figure represents Erichthonius, fourth King of Athens, the son of Vulcan and Minerva. He was deformed, it is said, and his inability to walk with ease led him to invent the four horse chariot. His invention secured for him a place in the sky, the celestial Hall of Fame.

> His art great Jove admir'd, when first he drove
> His rattling carr, and fix't the youth above.

According to another story, Auriga was the son of Mercury, and the Charioteer of Oenomaus, King of Pisa. He was reputed to be most skillful in the training of horses, and those trained by him were the fleetest steeds in Greece.

The constellation Auriga appears in the Greek star lists of Eudoxus (4th Century B.C.) and Aratos (3rd Century B.C.).

The star Capella has an interesting history. Mythologically, it represents the She Goat which suckled the infant Jupiter. The story runs that

Mythology—*Continued*

having in play broken off one of the Goat's horns, Jupiter endowed the horn with the power of being filled with whatever the possessor might wish, whence it was called "the Cornucopia," or "Horn of Plenty."

In India, Capella was worshipped as the Heart of Brahma. The ancient Peruvians called it "Colca" and connected it with the affairs of Shepherds. English poets have also alluded to it as "the Shepherd's Star."

On an old tablet in Akkadian there is inscribed an allusion to Capella, it being designated as "the Star of Stars." This is the most ancient reference to the star extant.

Capella's place on the Denderah Zodiac is occupied by a mummied cat, in the outstretched hand of a male figure crowned with feathers. The star was the object of worship in the great temple of Karnak in Egypt. To the Arabs Capella was known as "the Driver," because it seemed to rise earlier than the other stars and so, apparently, watched over them; or, still more practically, as "the Singer" who rode before the procession cheering on the camels, which last were represented by the Pleiades.

Capella was regarded by the early astrologers as having a stormy character, and associated with inclement weather, and it was sometimes called "the rainy Goat Starre." It portended civic and military honors and wealth.

AURIGA

For the Naked Eye and Field Glass

Auriga is a beautiful and conspicuous constellation. It is characterized by a clearly defined pentagon of stars. Note the three fourth magnitude stars near Capella forming a triangle. They were known to the Arabs as "the Kids."

The star Nath, or beta Tauri, is common to the constellations Auriga and Taurus. It represents the right foot of the Charioteer, and one of the tips of the Bull's horns.

On the night of January 23, 1892, Dr. Anderson discovered a new star a few degrees from beta Tauri at a point about one-fifth of the distance between that star and theta Aurigæ. It reached fourth magnitude at maximum and declined to sixteenth magnitude in April. In August, Corder found that it had risen again in brightness to ninth magnitude. From observations made at the Lick Observatory the spectrum of this Nova resembled that of a planetary nebula.

The feature of the constellation Auriga is alpha Aurigæ or Capella, (Kă-pĕl′-lă), meaning the "She Goat." Eudosia thus praises it:

> And scarce a star with equal radiance beams
> Upon the earth.

In these latitudes it is visible at some time every clear night throughout the year. Of the first magnitude stars it is nearest to the Pole, and it rises almost exactly in the northeast.

Capella is 47 light years distant and is receding from us at the rate of 19 miles a second. Its spectrum is much like that of our sun and it is 150 times brighter.

In brightness Capella ranks third of all the stars seen in these latitudes. Its magnitude is 0.2 and its total mass is 4 times that of the Sun. (See diagram p. 502.)

(Continued on page 106.)

For the Naked Eye and Field Glass—*Continued*

Capella is really a binary too close for telescopic observation. The companion was detected by the spectroscope. These two bodies form a double system, the components moving in orbits about their common center of gravity. The orbital period is 104 days. These close companion stars are in approximately the same physical condition, and almost of the same mass.

Ptolemy, El Fergani (10th Century) and Riccioli have all called Capella a red star. To us it appears brilliantly yellow or golden in color. Capella culminates at 9 P.M. on January 19th.

β Aurigæ is a star of especial interest. Professor Russell thus refers to it: It consists of a pair of stars of equal size and brightness, and very nearly equal mass, which revolve around their common center of gravity in circular orbits lying in a plane inclined 12° 49′ to the line of sight, with a period of 3 days, 23 hours, 2.5 minutes, and mutually eclipse one another at every revolution.

The actual distance between the centers of the two stars is 7,630,000 miles and each star is 2,200,000 miles in diameter. The more massive component has 2.38 times the mass of our sun, and the other 2.34 times. The whole system is at a distance of about 10,000,000 times that of the sun, so great that light takes 160 years to travel over it.

Each of the two stars gives out nearly 20 times as much light as does the sun.

The light of ζ Aurigæ is singularly intense for its magnitude. λ Aurigæ is 49 light years distant, according to a recent measure.

The region in the vicinity of ι Aurigæ is an interesting one for those who have an opera or field glass.

(*See For the Telescope, p. 108*)

AURIGA

Herschel's Telescope
Menkalinan
2
β
4
δ
3
θ
AURIGA
Capella
(Creamy White)
1
The Goat
α
Solstitial Colure
37 M.
3
ε
3
η
4
ζ
The Kids
Perseus
β Tauri
2
Nath
38 M.
3
ι
Taurus

For the Telescope

Auriga is rich in telescopic objects of interest. The data relating to the double stars follows, including two in the neighboring constellation Perseus. Their location is indicated on the Chart.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ω	4–8	6	354	Color estimates discordant.
26 Triple	5.8–8.0–11.0	12	268	Yellow–Blue.
14 Triple	5–7.2–11.0	14	225	Yellow–Blue.
41	5.2–6.4	8	353	White–Violet.
λ	5–9	121	13	
Σ 872	6–7	11	217	Yellow–Lilac.
Σ 645	6–8	12	27	White–Ash.
Σ 681	6.5–9	23	181	
Σ 698	6.0–7.7	31	346	Yellow–Bluish. Beautiful.
Σ 764	6–7	26	14	
56	5.5–8	48	21	
Σ 533	6–7.5	20	60	In Perseus.
Σ 552	6–6	9	114	In Perseus.

The field within the pentagon is particularly rich in clusters. To sweep over this region with a field glass is a delight. The region about ε is also attractive.

Smythe describes the cluster 1119 as "an oblique cross, with a pair of large stars in each arm, and a conspicuous one in the center, the whole followed by a bright star of the 7th magnitude."

There are several wide doubles scattered through it and the whole region is very beautiful.

Of the cluster 1295 Webb says: "Even in small instruments it is extremely beautiful. One of the finest of its class."

Σ661
1
Capella
α
4
ε
Σ552
PERSEUS
Σ533
δ
41
2
β
4
η
4
ζ
λ
Σ616
1067
996
56
1451
1119
M38
3
ι
3
θ
Σ698
1166
1101
14
Σ672
M37
1295
26
Σ764
2
Nath
Σ645

CANCER

CANCER (kan′-ser)—THE CRAB (Face West)

LOCATION.—The zodiacal constellation Cancer lies between the constellations Gemini and Leo. A line drawn from β Tauri to Pollux in Gemini, prolonged about 15°, ends in Præsepe, the notable star cluster in Cancer. This cluster is also known as "the Bee Hive," and "the Manger."

An imaginary line drawn from Capella in Auriga through Pollux in Gemini points out alpha Cancri, which bears the Arab name "Acubens."

Mythology

. . . and there a Crab
Puts coldly out its gradual shadow-claws.

MRS. BROWNING.

Macrobius tells us that the name "Cancer" was selected by the Chaldeans to represent this constellation, because the crab, being an animal that walks backwards or obliquely, well typifies the sun's apparent retrograde movement when it is in this part of the zodiac.

The name "Tropic of Cancer" is now applied to the circle on the earth which marks the points at which the sun at noon is overhead at the summer solstice. It thus marks the northern boundary on the earth of the points where the sun is ever seen in the zenith. In this way the name "Cancer" has become familiar to all.

The Star cluster Præsepe, or the "Bee Hive," has quite an interesting history, for in ancient times it was regarded as a sort of barometer or weather guide. Pliny thus refers to the cluster.

"If Præsepe is not visible in a clear sky, it foretells the coming of a violent storm."

The stars γ and δ on either side of the "Bee Hive" bear the names "Asellus Borealis" and "Asellus Australis" respectively, Greek star names that mean the Northern Ass, and the Southern Ass. The Greeks and Arabs imagined that these two stars represented two asses feeding at the manger, represented by the star cluster.

The following story accounts for the presence of the two asses referred to:

Once upon a time, the god Bacchus, while on his way to the temple of Jove, came to a marsh which barred his way. He perceived two wild asses browsing in a field near by, and mounting one, crossed the marsh dry shod. In gratitude for this service he transported both creatures to the heavens.

According to the Greek legend, while the valiant Hercules was engaged in his famous contest with the dreadful Lernæan monster, Juno, envious of his fame, sent a crab to attack him, but Hercules quickly despatched it. Juno, to reward the crab for the sacrifice, persuaded Jupiter to immortalize the creature by placing it among the stars.

Acubens, the Arab name for the star alpha Cancri, means "the Claws."

For the Naked Eye and Field Glass

The feature of this constellation is the coarse cluster known as Præsepe, pronounced prē-sē′-pe. The words means Manger. It is more familiarly known as "the Bee Hive."

The Bee Hive lies within an irregular square formed by the faint stars, γ, δ, η, and θ. To the naked eye the cluster resembles a nebula, and it has been mistaken for a comet.

The first sight of these stars by Galileo filled him with delight and amazement. It was one of the first conquests of his telescope. The cluster is a fine sight in a field glass.

For further details concerning this cluster, see paragraphs under "For the Telescope."

If your field glass is a powerful one, and you hold it steadily, you may be able to separate the double star ι Cancri.

In June, 1895, all the planets, excepting Neptune, were in this region of the heavens, and Halley's comet was in this constellation on its first appearance in 1531.

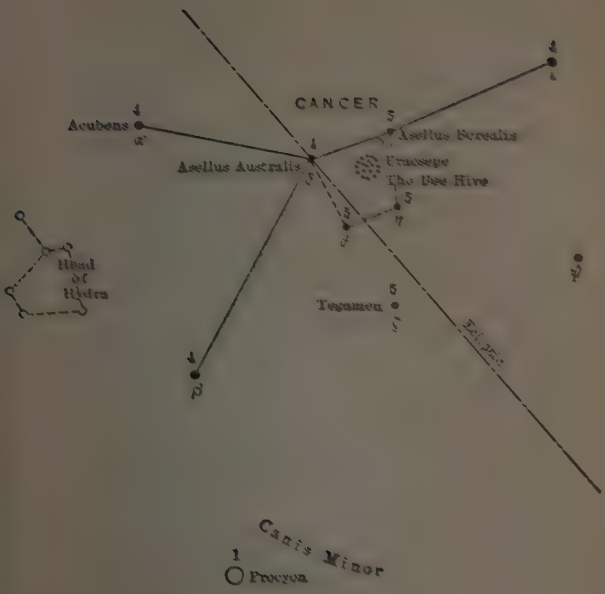
The constellation Cancer is due south about 8 P.M. April 1st. In the early evenings in mid-spring it can be observed in the southwest, well up the sky.

β Cancri lies about 10° northeast of Procyon, the brilliant star in the constellation Canis Minor. Alpha Cancri lies on the same line, 10° above β. These two stars form the tips of an inverted letter "Y." This figure "Y" is directly above the stars in the head of the Hydra. See Chart.

The planet Jupiter is in Cancer the latter part of 1931 and the first part of 1932.

Procyon is a star of the solar type. It is 10 light years distant, and has a proper motion of 12 miles per second. For full details see Canis Minor.

CANCER


CANCER
Acubens
α
Asellus Australis
Asellus Borealis
Praesepe
The Bee Hive
Head of Hydra
Tegamen
Ecliptic
Canis Minor
Procyon

For the Telescope

Cancer is the most inconspicuous of the zodiacal constellations. It contains, however, a good number of double stars. The data is given below and includes doubles in the constellations of the Lynx, Hydra, and Canis Minor situated in this region. The Chart indicates the location of these stars.

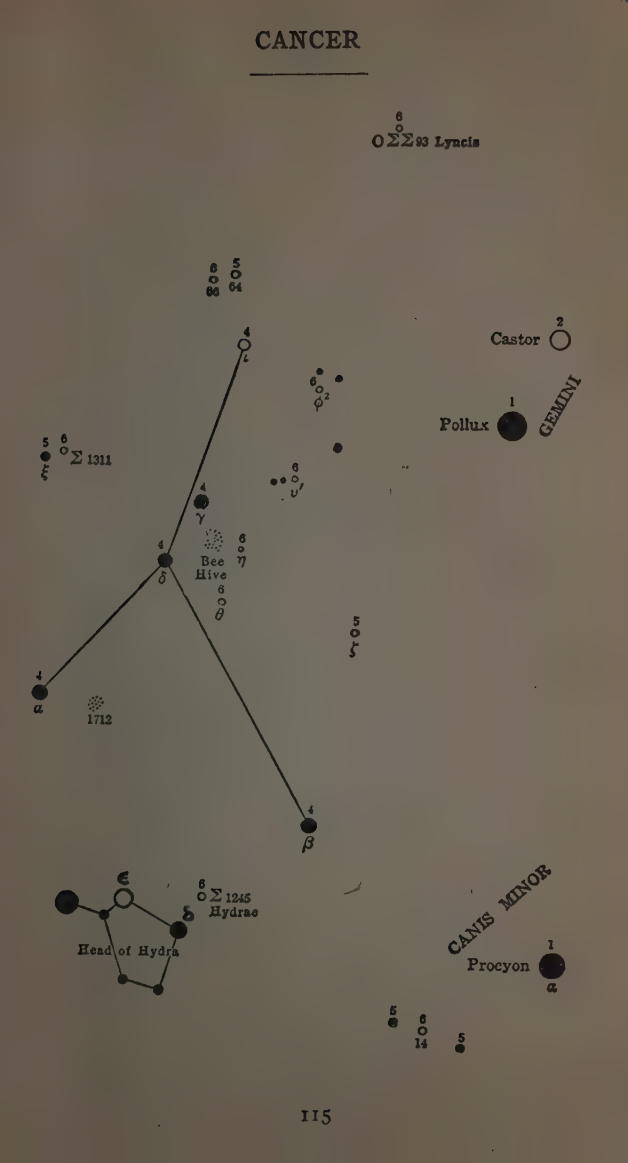
Double Star	*Magnitude*	*Distance, Seconds*	*Angle Degrees*	*Remarks*
ι	4.2–6.6	31	307	Yellow–Blue. Fine contrast.
ψ^1	6–7	6	37	
ζ	4.8–6–5.7	5	115	Triple. Two stars visible in small telescope. Yellow–Orange.
Σ 311	6.7–7.1	7	200	
θ	6.1–8.2	4	137	Use power of 160.
ϕ^2	6.0–6.5	5	212	
64	5.5–9.0	89	294	
66	6–8.2	5	138	
93 Lyncis	6–8	76	168	Gold–Azure.
Σ 1245	6–7	10	25	In Hydra.
14	6–7–8	115	154	Triple. In Canis Minor.
		75	65	
ε Hydrae				See p. 120

As with the naked eye, the outstanding telescopic feature of Cancer is the "Bee Hive."

The Bee Hive contains a total of 358 stars down to the 18th magnitude. Eighty stars in the cluster are brighter than the 10th magnitude, and there are 100 stars which are brighter than the sun; of these, 20 are 10 times the sun's brightness. The cluster is 450 light years distant.

(Continued on page 116.)

CANCER


6
Σ93 Lyncis
6
66
5
64
4
ι
Castor
2
6
φ²
Pollux
1
GEMINI
5
ξ
6
Σ 1311
6
υ'
4
γ
4
δ
Bee
Hive
6
η
6
θ
5
ζ
4
α
1712
4
β
ε
6
Σ 1245
Hydrae
δ
Head of Hydra
CANIS MINOR
1
Procyon
α
5
6
14
5

For the Telescope—*Continued*

Schwarzchild discovered spectroscopically that the brighter stars in the cluster are all receding from the sun at the same rate, and noted that this rate is almost the same as in the case of the Hyades cluster in the constellation Taurus. Præsepe and the Hyades are really twin clusters, being similar in size, brightness, motion and origin. They are moving southeasterly in parallel lines at the rate of 25 and 27 miles a second respectively.

Professor Russell informs us that the bright central portion of the "Bee Hive" is approximately 10 light years in diameter, while the outer stragglers extend through a region more than 30 light years across.

ζ Cancri is an interesting double star. According to Professor Russell, it has two stars in orbital motion about one another, which have completed two revolutions since the first observations by Herschel in 1780, the period being 60 years. At present they are near their widest separation, at an apparent distance of 1″ of arc, and can be seen double with a 4-in glass. When closest in 1870, they were only half as far apart. The third member of the system is in slow revolution about the center of gravity of the binary pair but in an opposite direction. So far, its motion has been nearly uniform, and if this continues to be the case, the period of revolution will be about 700 years. It is supposed to have a "dark" companion of mass comparable with itself, and the pair are revolving around a common center of gravity in a period of 17.6 years.

Observe Castor, that gem of double stars in this region of the sky.

An occultation of γ Cancri by the moon frequently occurs. This is always an interesting sight. The student should consult the Nautical Almanac, which can be secured from the Superintendent of Documents in Wash-

(*Continued on page 117.*)

For the Telescope—*Continued*

ington, D. C. In this book the dates and times of occultations visible in these latitudes are recorded.

The cluster 1712, which is M 67 in Messier's Catalogue, is an interesting object. It is composed of stars of magnitude 9 to 12.5, surrounded by brighter stars in the form of a semicircle. The cluster as a whole resembles a nebula in a small instrument.

A powerful field glass should split the double star ι Cancri. It was discovered by Herschel in 1782.

To observe Cancer to advantage requires a dark clear night and all artificial light should be excluded from the eye.

Above Cancer is the little asterism of the Lynx composed of faint stars. It was invented by Hevelius in 1690, and is said to derive its name from the fact that only a lynx-eyed person can see it. The asterism is rich in double stars.

HYDRA

HYDRA (hi′-dra)—THE SEA SERPENT
(Face Southwest)

LOCATION.—The head of Hydra, marked by a striking and beautiful group of stars, lies just below the Bee Hive in Cancer, and six degrees south of alpha Cancri. The group forms a rhomboidal figure of five stars. See Diagram of Cancer.

HYDRA

Mythology

But lo! afar another constellation,
They call it Hydra. Like a living creature
'Tis long drawn out. His head moves on below
The midst of the Crab; his length below the Lion;
His tail hangs o'er the Centaur's self.

ARATOS.

According to an old legend, the Hydra was the terrible monster that lived near the marshes of Lerna. The creature had many heads which were peculiar in this respect, as fast as one was cut off, two immediately grew in its place.

Hercules and his nephew Iolaus sought the monster to slay it, and as fast as Hercules cut off a head, Iolaus seared the wound with a hot iron, which prevented other heads from growing out.

The central head of the monster was supposed to be immortal, and this one Hercules buried under a rock.

The long extended and serpentine figure of Hydra somewhat resembles a wandering stream. This led the Egyptians to imagine that this constellation was the heavenly counterpart of their famous River Nile.

For the Naked Eye and Field Glass

The constellation Hydra is about one hundred degrees in length, and reaches almost from Canis Minor to Libra. Its stars are faint with the exception of alpha Hydræ, a second magnitude star which bears the Arab name Alphard which means "the Solitary One." Alphard is a red star, and is located in the heart of the creature. It is sometimes called "Cor Hydræ."

Alphard is remarkable for its isolated position. The star is located southwest of Regulus in Leo. A line drawn from gamma Leonis through Regulus, points to Alphard. Castor and Pollux are also pointer stars to alpha Hydræ (Alphard), which lies to the southeast of the Twins.

The constellations Corvus, the Crow, and Crater, the Cup, are associated with Hydra as they both stand on the coils of the Sea Serpent, south of Denebola, the second magnitude star in the tip of the Lion's tail.

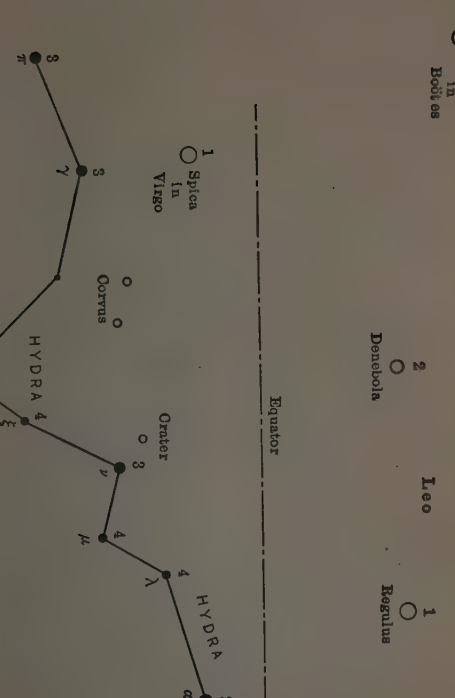
The little asterism Sextans, the Sextant, lies in this region between Regulus and Alphard. It contains no stars brighter than the fourth magnitude.

For the Telescope

For the telescopists, see the double stars in Hydra cited under chapters on Cancer, Corvus, and Crater.

The star ϵ Hydræ, in the Hydra's head, is an interesting star. It was discovered to be a double by Struve. In 1888 Schiaparelli noted that the brighter component was itself a close double. The system is 135 light years distant. Its period is 15 years. The brighter pair are of 3.8 and 7.8 magnitude, separated at a distance of 3.2″, at an angle of 195°. See Diagram of Cancer, p. 115.

HYDRA


1 Arcturus in Boötes
2 Denebola
Leo
1 Regulus
Cancer
Equator
1 Spica in Virgo
Corvus
Crater
HYDRA
2 Alphard The Heart of Hydra (Red)
HYDRA

LEO

LEO (le′-o)—THE LION (Face South)

LOCATION.—A line drawn from Pollux in Gemini, to γ Cancri, prolonged about 12°, locates the first magnitude star Regulus in the heart of the Lion.

Regulus lies about 9° east of Cancer, and about 12° northeast of Alphard in Hydra.

Mythology

'Neath her hind feet as rushing on his prey
The lordly Lion greets the God of day.

ARATOS.

Leo is an extremely ancient constellation. From the earliest times it has been associated with the sun.

According to Pliny, the early Egyptians worshipped the constellation Leo because the Nile inundation occurred, in ancient times, when the sun entered this constellation.

Some believe that the Sphinx represents Virgo's head on Leo's body.

The name Regulus, borne by the star alpha Leonis, means "the Little King." The star was named by Copernicus. It has also been called "the King," "the Mighty," "the Great," "the Hero," "the Ruler."

The early Persians regarded Regulus as one of the four Guardian stars of Heaven, the others being Fomalhaut, Aldebaran, and Antares.

Four thousand years ago the longitude of this star was measured in Babylon, and two thousand years later by Hipparchus. Later on, his observations of Regulus and Spica led to his discovery of the Precession of the Equinoxes.

The figure of Leo, very much as we have it, appears in all the Indian and Egyptians zodiacs.

For the Naked Eye and Field Glass

With an opera or field glass the companion stars near α and γ Leonis are worth observing. These are probably "optical" doubles, that is: one star is nearer to us than the other, though they appear to be side by side in the sky.

An opera or field glass will separate the components of the double star τ Leonis. (See Telescope diagram, p. 127.)

Leo is one of the most beautiful of the constellations of the Zodiac. It lies south of the Great Bear and its principal stars are arranged in the form of a sickle, or a reversed "?", which marks the Lion's head. Regulus is in the handle of the sickle. It is one of the stars from which longitude is reckoned, and lies almost exactly on the Ecliptic. Regulus is 56 light years distant, and is receding from us at the rate of 3 miles a second. It is 70 times brighter than the sun.

(Continued on page 124.)

For the Naked Eye and Field Glass—*Continued*

Regulus is a white star of the Orion type, and is visible for eight months in the year. It rises a little north of east about 9 P.M. on New Year's eve, and culminates at 9 P.M. April 6th.

The hindquarters of the Lion are defined by a right angle formed by the stars β, δ, and θ Leonis. Denebola, a star of the second magnitude, marks the tip of the Lion's tail. It lies 25° east of Regulus, and about 35° west of Arcturus in Boötes. It is the same distance northwest of Spica, in Virgo, and forms, with Spica and Arcturus, a large equilateral triangle.

Denebola is 32 light years distant, and is receding from us at the rate of one mile a second. It is 11 times as bright as the sun. It comes to the meridian at 9 P.M., May 3rd.

γ Leonis is one of the finest double stars in the heavens. It is approaching us at the rate of 24 miles a second.

δ Leonis is 39 light years distant, and approaching at 9 miles a second.

The star omicron Leonis is 95.8 light years distant.

November is a famous month for meteors. A shower known as "the Leonids" radiates from the head of the Lion, marked by the sickle. It is due on the 14th or 15th of the month. These meteors were wonderfully numerous in 1833 and 1866, when there were marvelous displays. Since then they have not been seen in such vast numbers.

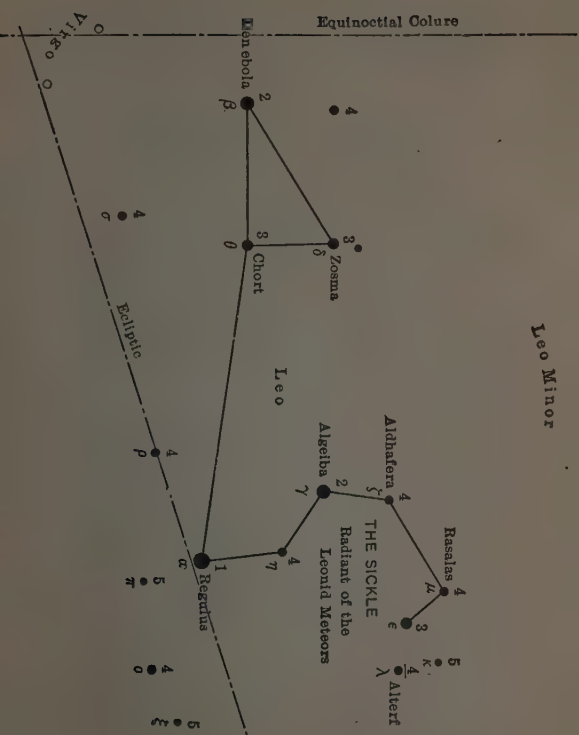
Calculations show that this great meteoric swarm has been drawn wide from its orbit by the attraction of the planets Jupiter and Saturn.

The Leonids are remarkable for their swiftness, and their light is of a deep bluish color. They are following about the sun the exact path of Tempel's Comet, and it is thought that they are the remains of this Comet.

The planet Neptune will be in this constellation from 1929 to 1933 inclusive. It is visible only in a telescope.

Jupiter is in Leo the latter part of 1932 and the first part of 1933.

LEO



Equinoctial Colure
Virgo
Denebola
Chort
Zosma
Ecliptic
Leo
Leo Minor
Algeiba
Aldhafera
Rasalas
THE SICKLE
Radiant of the
Leonid Meteors
Regulus
Alterf
Cancer

For the Telescope

The following double stars will be of interest to telescopists, and the list contains one beauty.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
γ	2.6–3.8	3	117	"Finest double in the northern sky." Struve.
τ	5.4–7	90	170	Lemon–Light blue. Field-glass double.
54	5–7	6	102	Fine object.
93	4.7–8.4	74	355	
90	6–7.3	5	204	
6	5–9.5	37	74	
7	6–8	42	356	
88	6.4–8.4	15	320	

The telescopic feature of the constellation is the double star γ Leonis. It is best observed when it is not quite dark, or in moonlight. The colors of the two stars are yellow and green. This star is a well known binary in very slow motion. A complete revolution can hardly take less than 1,000 years.

Regulus has a companion of the eighth magnitude, a little less than 8 minutes of arc distant, which shares the proper motion of its primary. It is a double star. Miss Clerke mentions its color as "seemingly steeped in indigo." It is a difficult object for a 3 in. telescope.

Note the double 35 Sextantis. 6–7, Distance 6″, Angle 24°. β has a companion of the eighth magnitude.

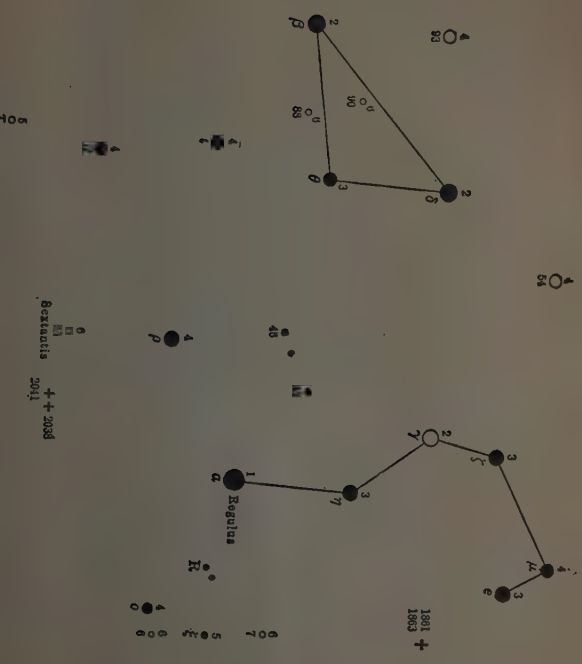
Note the nebula 1861–1863, large and brilliant, a double nebula in large telescopes.

The noted long period Variable Star, R Leonis, is located on the Diagram at the point marked "R." It varies from the fifth to the tenth magnitude in 144 days. It is a red star and at maximum is, of course, visible to the naked eye and well worth observing.

ζ has three companion stars.

ε has two seventh magnitude companions forming a beautiful little triangle.

Refer to Nautical Almanac for exact position of Neptune; in Leo 1929 to 1933 inclusive.


Regulus
Sextantis
1861
1863
2041
2038

COMA BERENICES

COMA BERENICES (kō′-ma ber-e-nī′-sez)—BERENICE'S HAIR (Overhead)

LOCATION.—A line drawn from Regulus, the first magnitude star in Leo, to δ Leonis, prolonged an equal distance, locates this scattered cluster of faint stars. The cluster is 18° northeast of δ Leonis, and lies within a triangle formed by Denebola in Leo, Arcturus in Boötes, and Cor Caroli in Canes Venatici.

Mythology

Now behold the glittering maze of Berenice's hair.

The famous legend relating to this beautiful star cluster is as follows:

There was once upon a time a lady of great beauty named "Berenice." She was of a royal family, and happily married to Euergetes, one of the ancient Kings of Egypt. When the King was about to set out on a dangerous expedition, Berenice was so fearful that harm would befall him, that she vowed to dedicate her beautiful hair to the goddess of beauty if he should return in safety. Good fortune attended him, and on his return Berenice, true to her vow, cut off her beautiful tresses and placed them in the temple of Venus.

Later on, they were missed from the temple, but Conon, the Astronomer Royal, assured the King that Jupiter was so inspired by Berenice's sacrifice that he had taken her tresses from the temple and enshrined them forever among the stars. He proved the statement by pointing out to the King and people the glittering star cluster known ever after as "Berenice's Hair." In the National Museum at Naples, there is a beautiful bronze bust of Berenice.

For the Naked Eye and Field Glass

As the cluster is a faint object it should be observed on a clear and moonless night. Twenty or thirty stars can be counted in the cluster with an opera glass. Webb thus refers to the constellation: "A gathering of stars which obviously require distance only to become a nebula to the naked eye."

In this constellation it is estimated that over a hundred nebulæ are located in a space no greater than that which is covered by the full moon. Unfortunately they are too faint to be observed with a small glass.

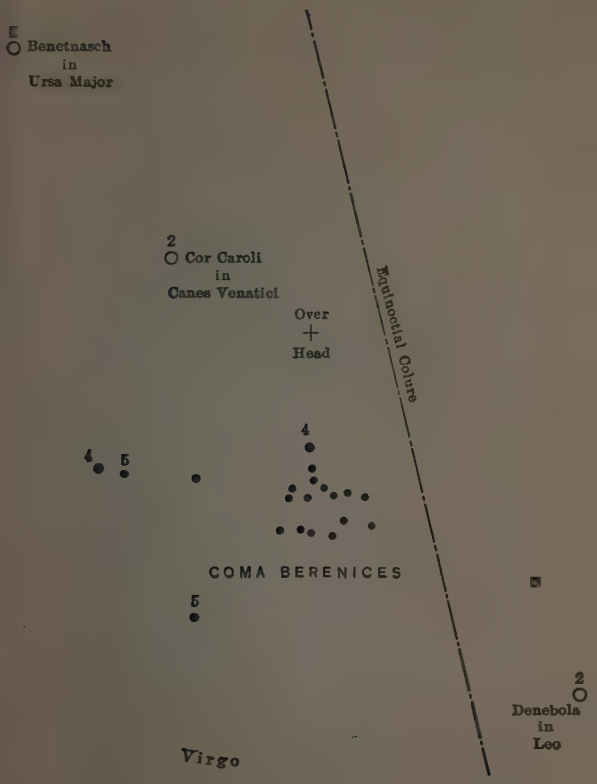
It is estimated that this cluster is between three and four hundred light years distant.

Dr. Seiss associates a bright star, which appeared in this constellation, with the Star of Bethlehem, which he says was vertically overhead at Jerusalem on the 25th of December at the time of Christ's birth. A century and a half after Christ, in the days of Ptolemy, the star was so faint as hardly to be distinguishable.

A meteor shower, which occurs March 20th, radiates from Coma Berenices. The meteors in this shower appear as swift streaks across the sky.

The first half of the month of April may be regarded as the most brilliant sidereal period of the year. At this time twelve first magnitude stars are visible in this latitude at 9 P.M. From east to west they are: Vega, Arcturus, Spica, Regulus, Castor, Pollux, Procyon, Sirius, Capella, Aldebaran, Betelgeuze, Rigel,—a glorious company.

COMA BERENICES

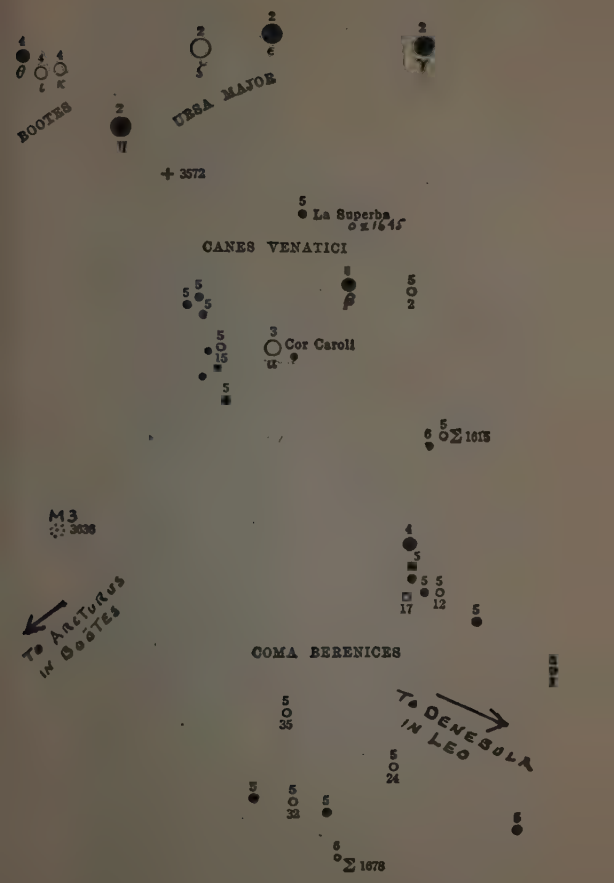


For the Telescope

The double stars cited below should be of interest to the amateur. The Chart indicates their location.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
24	4.7–6.2	20	271	Orange–Lilac. Fine contrast. Yellow–very blue also given.
12	5–8	66	168	
17	4.8–6	145	250	White–Lilac.
35	5–8	28	124	Lilac–Blue.
2	6–7	3.6	240	
32	5.3–6.1	194	48	
Σ 1678	6.3–7	32	211	

COMA BERENICES



CANES VENATICI

CANES VENATICI (kā′-nēz ve-nat′-i-cī)—THE HUNTING DOGS (Overhead)

LOCATION.—Cor Caroli, the brightest star in this constellation, a star of 3.2 magnitude, when on the meridian is about 17° south of ε Ursæ Majoris. A line drawn from η Ursæ Majoris, through Berenice's Hair to Denebola, on Leo, passes through it.

For the Naked Eye and Field Glass

The hunting dogs bear the names "Asterion" and "Chara" and are represented as being held in leash by Boötes, the Herdsman, as he pursues the Great Bear about the Pole. Cor Caroli is located in Chara, the southern of the two hounds.

The figure known as "the Diamond of Virgo," a stellar landmark in this region of the sky, should be observed. It is a perfect diamond formed by joining with imaginary lines the stars Cor Caroli, Arcturus, in Boötes, Spica in Virgo, and Denebola in Leo.

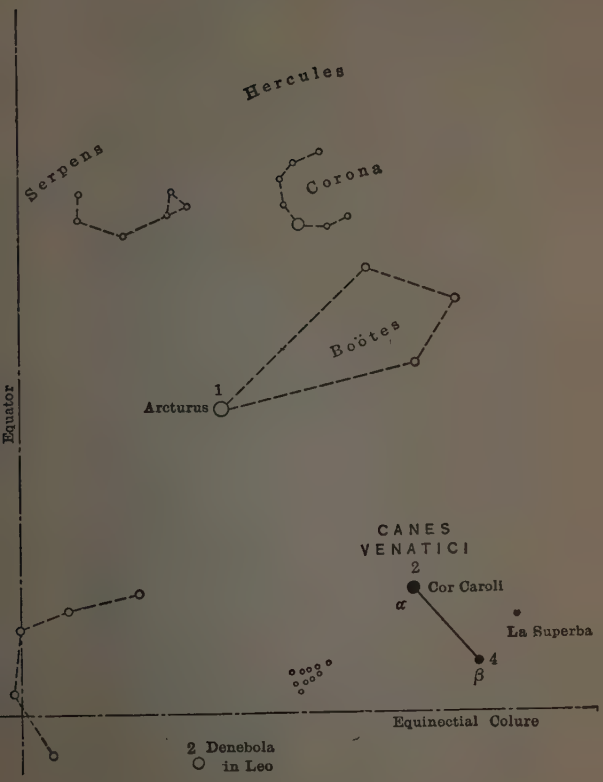
Cor Caroli was named by the Astronomer Royal, Halley, at the suggestion of Sir Charles Scarborough, the Court Physician, in honor of Charles I of England. It represents the heart of the monarch. This is one of the few cases where a fairly modern star name relating to a personage has attained permanency, and become a recognized feature in the sky.

Cor Caroli is on the meridian at 9 P.M. May 20th.

Observe the star La Superba with an opera glass.

The star numbered 15 is a double. (See diagram, p. 137.) It can be separated with a good field glass if it is held steadily.

CANES VENATICI



For the Telescope

The following double stars are a partial list of the many interesting doubles in this constellation:—

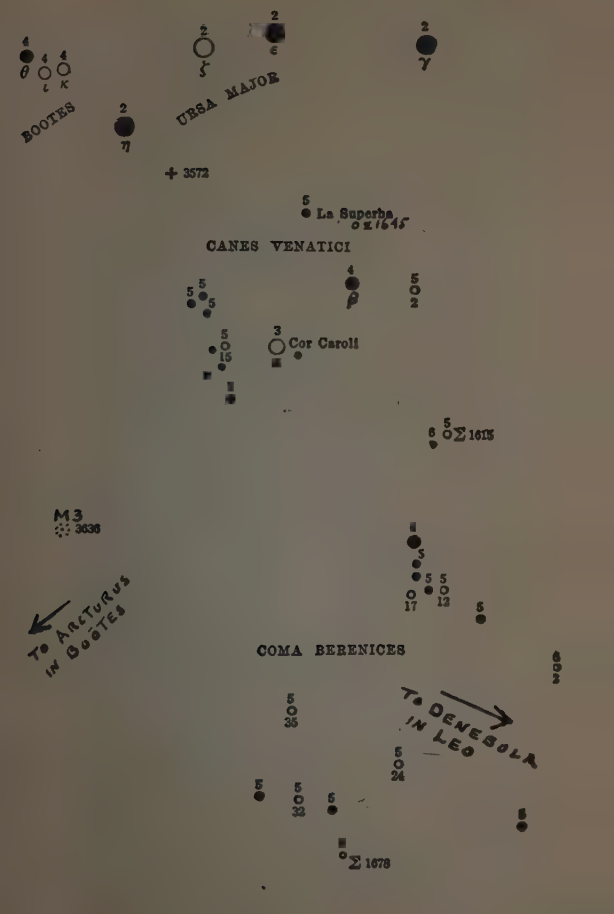
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α (cor Caroli)	3.2–5.7	20	227	Both yellow. Easy for a small glass. Can be seen in a 2 inch telescope.
2	6–8	11	260	Red–Blue. Fine contrast.
15	5.5–6	290	297	Field glass double.
Σ 1615	6–8	27	88	Yellow–Ashy.
Σ 1645	7–7.5	10	161	Webb says "a lovely pair as I ever saw."

Seven degrees northwest of Cor Caroli is "La Superba," a fifth magnitude star of a brilliant red color. It is one of the few stars of the 4th spectral class, and is noted for the splendid color of its flashing rays.

The nebula 3572 is the famous "Spiral, or Whirlpool Nebula" of Lord Rosse. A powerful telescope is required to reveal its wonderful details.

The cluster 3636 (M 3), on a line between Arcturus and Cor Caroli, is very remarkable. Recent measures of its distance, by indirect methods that are reliable, place it at the incomprehensible distance of 13,900 parsecs. A parsec is 3.26 light years. To cross the cluster, light must travel 470 years at the rate of 186,000 miles a second. Out of a thousand stars in the cluster one-seventh are Variable, all having a period of half a day, and their periods are known to the fraction of a second. Their light changes so rapidly that in one case it doubles in seven minutes.

CANES VENATICI



CANIS MINOR

CANIS MINOR (kā′-nis mī′-nor)—THE LESSER DOG
(Face West)

LOCATION.—Procyon, the Little Dog Star, lies about 23 degrees south of Pollux in Gemini. A line drawn from β Tauri to γ Geminorum prolonged about 18 degrees reaches Procyon.

Mythology

> The dog's precursor, too, shines bright beneath
> The Twins.
>
> ARATOS.

In ancient times the Little Dog was considered to be a water-dog because it stood on the border of the Milky Way, which was thought to be a river in the sky.

Mythology has assigned the Little Dog to various personages. It was natural to regard it as belonging to the Giant Hunter Orion, as it follows close on his heels in the sky. There is a legend, however, that relates that this is the faithful dog Mera, whose master Icarius had been murdered and his body had remained undiscovered. Erigone, his daughter, was grief striken at the failure to recover her father's

body. Meanwhile Mera searched diligently for it. His efforts were finally rewarded, and his barking brought Erigone to the spot. Grief, however, had crazed her, and in her despair she hung herself. The loyal Mera pined away with grief and died, but the gods rewarded his faithfulness by placing him among the stars.

The little dog is also said to represent one of the hounds of Actæon. According to the story, Actæon unwittingly surprised Diana as she was bathing at a pool in the forest. The indignant lady changed him into a stag. He was pursued by his own dogs and slain by them. For some reason Actæon's hound was rewarded with a place in the heavens.

Astrologically Procyon portended wealth, fame and good fortune. It comes to the meridian on the 24th of February.

For the Naked Eye and Field Glass

Procyon is equidistant from Betelgeuze in Orion, and Sirius in Canis Major, and forms with these stars a large equilateral triangle. It forms a large right-angled triangle with Pollux and Betelgeuze.

Procyon is a golden yellow star of 0.4 magnitude, 10 light years distant. According to Professor Russell it is probably about the size of Altair, the first magnitude star in Aquila. It is seven times as bright as the sun and several times as bright per square mile. Procyon is approaching our system at the rate of two miles a second.

This star is a very remarkable binary, having a faint companion discovered at the Lick Observatory in 1896. It is visible only in the largest telescopes. It is about one-third the mass of Procyon, but gives only one one-hundred-thousandth as much light.

The companion of Procyon is one of the smallest stellar masses concerning which we have any reliable knowledge. It is about one-fourth of the sun's mass.

Procyon rises in this latitude a little north of east about half an hour before Sirius, hence it was called "Procyon" from two Greek words signifying "before the Dog."

Four degrees northwest of Procyon is the third magnitude star β Canis Minoris which bears the Arab name "Gomeisa," meaning "watery-eyed." The few remaining stars in the constellation are faint.

For the telescopic objects in Canis Minor see Cancer, p. 115.

CANIS MINOR

1
Pollux
The Head
of
Hydra
Cancer
Ecliptic
4
β
1 Procyon
α
3
Gomeisa
β
CANIS MINOR
2
Equator
Monoceros
1
Betelgeuze
in
Orion
1
Sirius
in
Canis Major

CORVUS

CORVUS (kôr′-vus)—THE CROW (Face South)

LOCATION.—A line drawn from the Bee Hive in Cancer, through Regulus in Leo, prolonged about forty degrees, ends near the conspicuous quadrilateral of stars which distinguishes the constellation Corvus. This figure resembles the figure 4.

The brightest star in this region of the sky is Spica, in the constellation Virgo. It lies about ten degrees northeast of δ Corvi which bears the Arab name "Algorab."

A line drawn from γ to β Corvi, prolonged twice its length, locates the third magnitude star ι Centauri in the right shoulder of the Centaur. The bright stars in this constellation are not visible in this latitude.

Mythology

The figure of a Crow seems pecking at him.

ARATOS.

The constellations, Corvus and Crater, are pictured in the old atlases as standing side by side on the coils of Hydra, the Water Snake.

In mythology, these constellations are closely associated. According to the Greek legend: Apollo fell in love with Coronis, but, being of an extremely jealous disposition, he sent a crow to spy upon the object of his affections. The Crow discovered that Coronis was untrue to Apollo,

and informed him of the fact. To reward the crow for this service, Apollo placed the bird among the stars.

It is also said that Corvus takes its name from the daughter of Coronæus, King of Phocis, who was transformed into a crow by Minerva to rescue the maid from the pursuit of Neptune.

Another legend relates that the crow was once of the purest white, but was changed to its present sable hue for tale bearing.

The Chinese called Corvus "the Red Bird," the Romans and Hebrews knew it as "the Raven," and in very ancient times it has borne the titles "the Great Storm Bird," "the Bird of the Desert," "the Bird of the Great Seed," and "the Storm Wind." In Chaucer's time Corvus was called "the Raven."

The myth associating Corvus with Crater is as follows: Apollo is said to have sent the crow to bring some water for a sacrifice to Jupiter, but the bird tarried at a fig tree till the fruit became ripe, and then returned with a water snake in its claws, and a lie on its tongue, claiming that the snake had occasioned the delay. Apollo, perceiving the untruth, and to punish the crow, placed him among the stars with the Cup and the Snake. The latter was charged never to allow the crow to drink, so the Crow is forever tantalized with the Cup of water near at hand into which he can never dip his bill.

For the Naked Eye and Field Glass

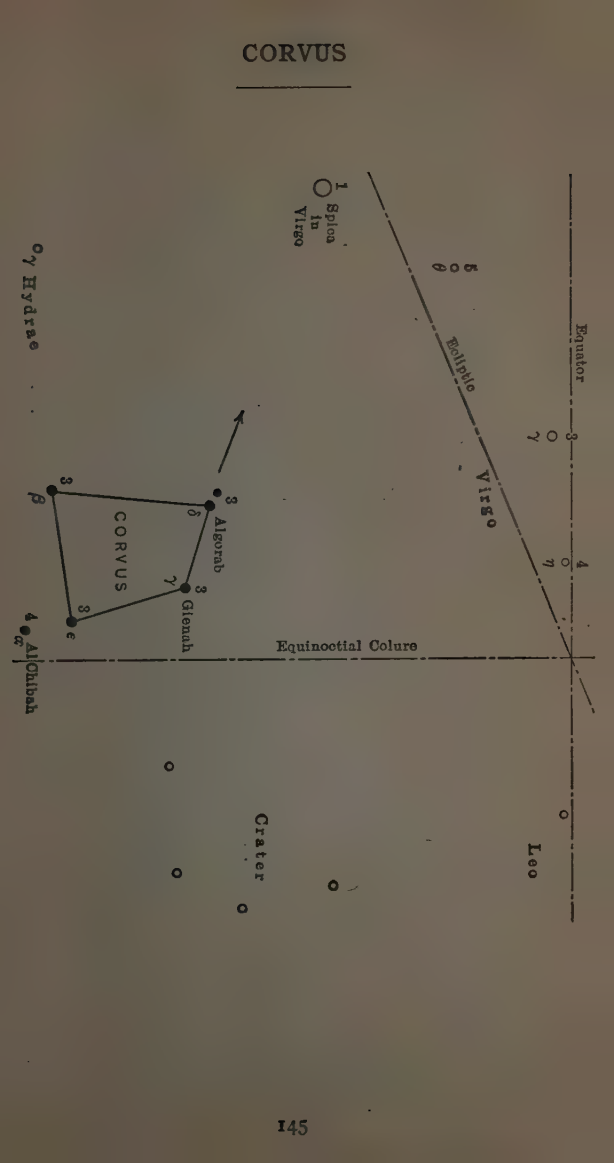
A small constellation containing little of interest visible to the naked eye.

For telescopic objects see Crater, page 149.

ζ Corvi, shown on telescopic diagram, has a companion star visible in a field glass.

The variable star R, shown on telescope diagram, can be picked up with a field glass when at, or near, its maximum of 7th magnitude.

CORVUS


Equator
3
γ
4
η
Virgo
Ecliptic
5
θ
1
Spica
in
Virgo
Leo
Crater
Equinoctial Colure
3
Algorab
δ
3
Gienah
γ
3
ε
3
β
CORVUS
4
α
Al Chibah
γ Hydræ

CRATER

CRATER (kra′-ter)—THE CUP (Face South)

LOCATION.—The constellation Crater is situated fifteen degrees west of Corvus, and due south of β Leonis. It is an inconspicuous constellation, but on a clear and moonless night it is easily distinguished. Six stars of the fourth magnitude form the bowl of the cup. They are arranged in the form of a semicircle.

The constellation resembles a round goblet with its base resting on the coils of the Hydra.

The star Alkes, alpha Crateris, is common to the constellations Hydra and Crater, and may be seen twenty-four degrees southeast of the star Alphard, the red and solitary star in the heart of the Hydra, the brightest star in this region of the sky.

Corvus and Crater are to be seen half way up the southern sky during the early evenings of Spring. Crater is on the meridian at 9 P.M. April 26th.

Mythology

. . . midway
His volume is the cup.
ARATOS.

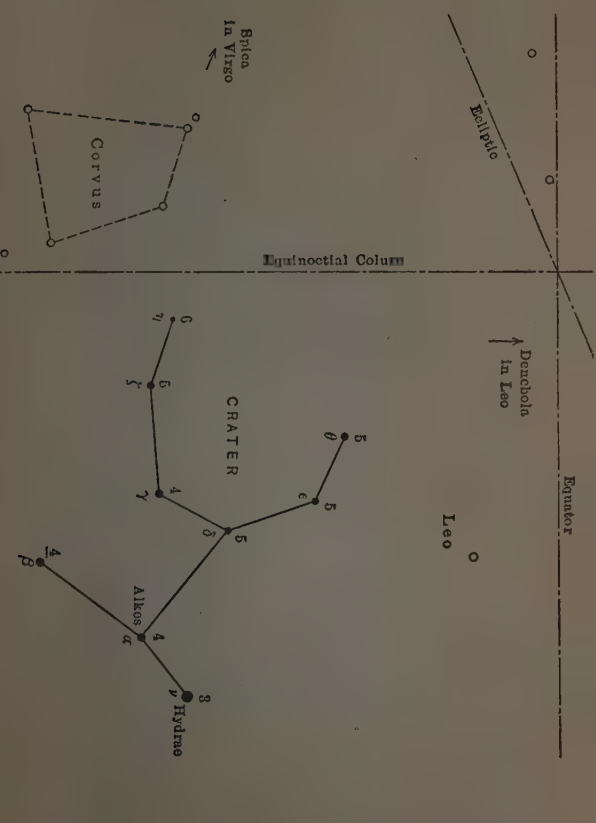
Crater has figured as the Cup of Apollo, Hercules, Achilles, Dido, Medea, Bacchus, Icarius, and even Noah's wine cup.

For the Egyptians, the rising of the constellation Crater was an event of some importance, as at this time the river Nile reached its greatest height, and the people knew that its flood would soon recede.

Crater was known in England two or three centuries ago as "the Two-Handed Pot."

In the old atlases of the constellations, the Cup is usually represented in the form of a large urn, elaborately ornamented, with two handles set opposite each other, a sort of loving cup.

CRATER


Equator
Ecliptic
Denebola
in Leo
Leo
Equinoctial Colure
Spica
in Virgo
Corvus
CRATER
5
θ
5
ε
5
δ
4
γ
5
ζ
6
η
4
β
4
α
Alkes
3
ν
Hydrae

For the Telescope

CRATER

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
Σ 1539	8–8	7	311	
Hh 376	6–6	9	211	In Hydra

Just west of ν Crateris is the double star Σ 1473, in Hydra. Magnitude 8.0–8.9; Distance 30.7″; Angle 10°.

21′ north of nu is the double 1474. Magnitude 7–8; Distance 71″; Angle 22°.

A line drawn from gamma to alpha Crateris, prolonged a little over its length, locates a remarkable planetary nebula in Hydra. "It will be seen like a pale blue disk, like the ghost of Jupiter." This nebula is just south of μ Hydræ, a fourth magnitude star.

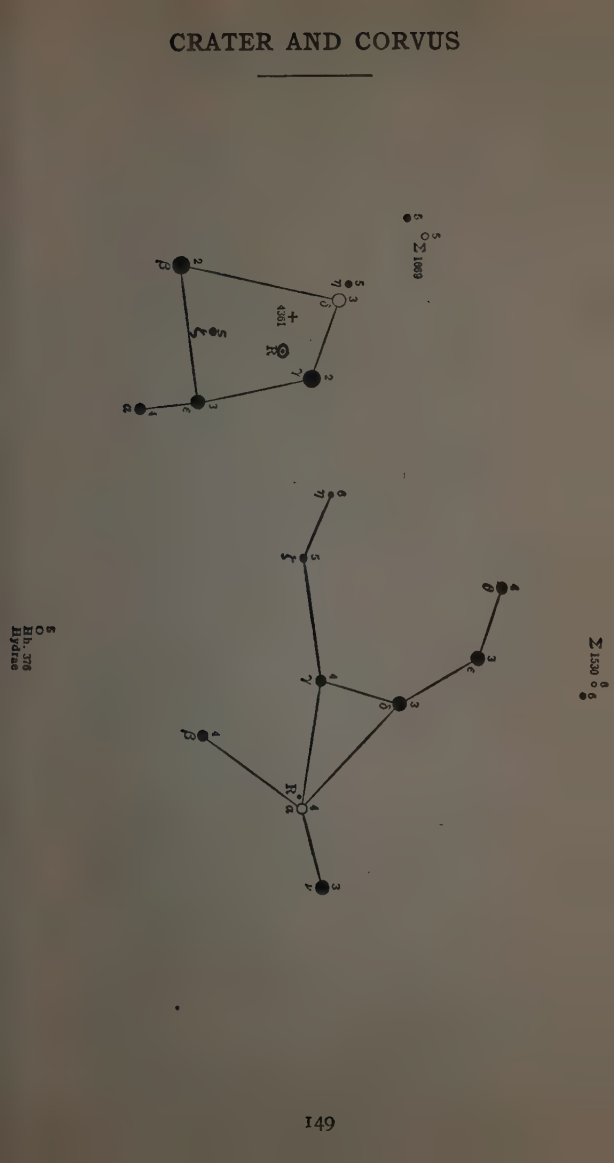
CORVUS

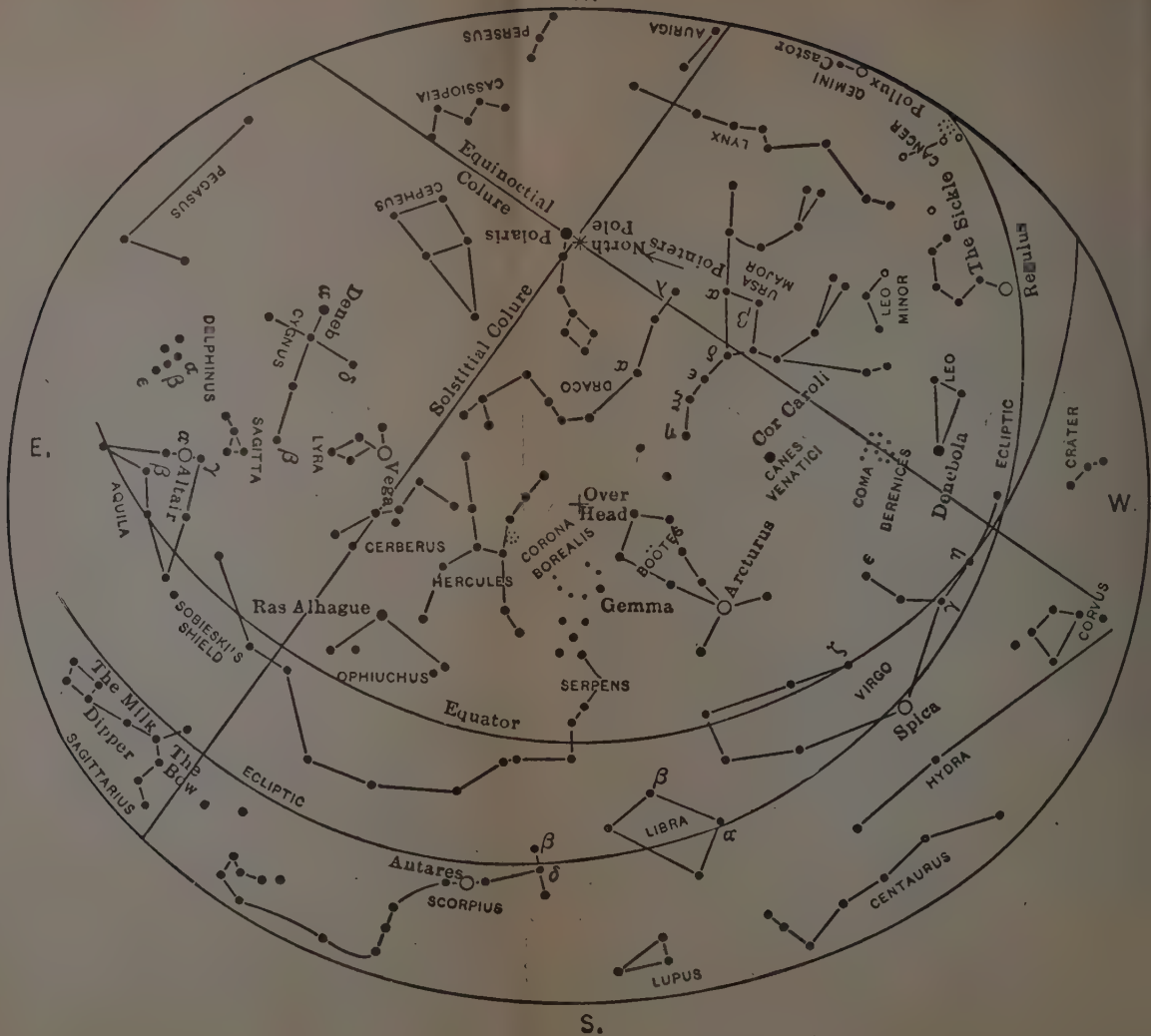
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
δ	3.0–8.5	24	214	Yellow–Purple. Fine contrast.
Σ 1669	6.5–6.5	5	299	

ζ Corvi has a companion star visible in an opera glass. Observe the nebula 4361.

In the case of the double star δ Corvi, its two suns are drifting together in a northwesterly direction with so high a speed, that they will change their position in the sky an amount equal to the apparent diameter of the full moon in the course of 7000 years.

The R on the Chart locates a famous long period Variable Star discovered by Karlinski in 1867. At maximum it reaches 7th magnitude, declining to 11.0 magnitude, with a period of 319 days. Variable Star observing is the most practical telescopic work that the amateur can engage in.


Σ 1669
4361
Σ 1530
Hb. 376
Hydrae


N.
S.
E.
W.
PERSEUS
AURIGA
Castor
Pollux
GEMINI
CANCER
CASSIOPEIA
LYNX
Equinoctial Colure
PEGASUS
CEPHEUS
Polaris
North Pole
Pointers
URSA MAJOR
The Sickle
Regulus
LEO MINOR
Deneb
CYGNUS
DELPHINUS
Solstitial Colure
DRACO
LEO
Cor Caroli
CANES VENATICI
COMA BERENICES
Denebola
ECLIPTIC
CRATER
SAGITTA
LYRA
Vega
Altair
AQUILA
Over Head
CORONA BOREALIS
BOOTES
Arcturus
CERBERUS
HERCULES
Gemma
Ras Alhague
SOBIESKI'S SHIELD
OPHIUCHUS
SERPENS
CORVUS
VIRGO
Spica
The Milk Dipper
The Bow
SAGITTARIUS
Equator
ECLIPTIC
HYDRA
LIBRA
Antares
SCORPIUS
CENTAURUS
LUPUS

THE CONSTELLATIONS OF SUMMER

The folded map opposite shows the principal stars visible from Latitude 40° N. at:

9:00 P.M. July 1st

9:30 June 22	8:30 July 8
10:00 June 14	8:00 July 14
10:30 June 7	7:30 July 22

The Times are Eastern Standard.

Chart held in this position depicts Southern sky. Quarter turns of the book from left to right give correct views successively of Eastern, Northern and Western sky.

DRACO

DRACO (drā′-ko)—THE DRAGON (Face North)

LOCATION—About ten degrees from alpha Ursæ Majoris (from alpha to delta Ursæ Majoris is ten degrees) is the star λ Draconis, a fourth magnitude star that marks the tip of the Dragon's tail.

Above λ, and almost in line with it, are two more stars in Draco, which form with two stars in Ursa Major a quadrilateral. See Diagram.

Draco now curves sharply eastward, coiling about the Little Bear, then turns abruptly southward, ending in a clearly defined group of four stars forming an irregular quadrilateral, which marks the Dragon's head. The constellation is a little difficult to trace out, but careful attention to the diagram should render the task fairly easy.

Mythology

Here the vast Dragon twines
Between the Bears and like a river winds.

According to an ancient myth, Draco is supposed to represent the monster that guarded the golden apples in the Garden of Hesperides. Hercules had a desperate encounter with the beast, finally succeeded in slaying it and carried away the precious fruit.

Draco was also said to be the dragon slain by Cadmus, the hero of Thrace. In this case, the monster was the guardian of a sacred spring. Cadmus was ordered to secure some of the water. He had a great battle with the monster before he finally despatched it. He plucked out its teeth, and sowed them in a field, whereupon a great number of warriors sprang up and engaged in a battle royal. There were only five survivors, and these assisted Cadmus to build the city of Bœotia, which was known as "the City of the Dragon." It is also related that in the war with the Giants, the goddess Minerva seized the Dragon, and hurled it into the northern sky where it became entangled in the axis of the heavens.

For the Naked Eye and Field Glass

Draco is almost overhead in the early evening during the summer months, and it is visible during the entire year.

The star marking the heel of Hercules, ι Herculis, lies just south of the Dragon's head. The brilliant Vega, in Lyra, will be seen about overhead, twelve degrees southwest of the Dragon's head.

γ Draconis, which bears the Arab name Eltanin, marks one of the Dragon's eyes. It is noted for its connection with the discovery of the laws of the aberration of light. Observations of the star by Dr. Hooke, lead Dr. Bradley to make the discovery which was announced in 1729. The rising of this star was visible about 3500 B.C. through the central passage of the temple of Hathor, at Denderah, in Egypt, where the star was an object of worship.

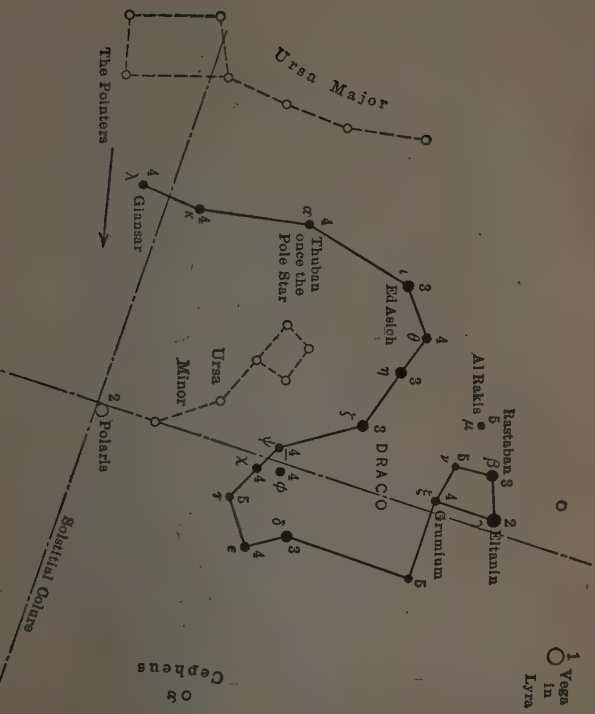
The star ν Draconis can be seen double with an opera or field glass if it is held steadily.

Vega, and the four stars in the Dragon's head, offer an opportunity of comparing stars of the first five magnitudes. Remember, the ratio of magnitude (that is, luminosity) is 2.5. For example: A standard first magnitude star is 2.5 times brighter than a star of the second magnitude, etc.

Alpha Draconis, known to the Arabs as Thuban, is an interesting star. Owing to the Precession of the Equinoxes it was the Pole star in 3500 B.C. See diagram p. 36. Thuban was worshipped by the Egyptians, and at one time it could be seen, by day and night, at certain times from the inner recesses of the Great Pyramid in Egypt. It is believed to have been brighter in ancient times than it appears now.

There are several meteoric showers that radiate from the constellation Draco, the most remarkable occurring on June 28th.

DRACO



Ursa Major
The Pointers
Giansar
Thuban once the Pole Star
Ed Asich
Al Rakis
Rastaban
Eltanin
Grumium
DRACO
Ursa Minor
Polaris
Solstitial Colure
Cepheus
Vega in Lyra

Draco is rich in double stars. A partial list follows:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ν	5–5	62	313	A grand object. Field glass double.
ψ	4–5	31	15	
40, 41	5.4–6	20	233	
17	5–6	3	116	
o	4.8–7.6	32	340	Orange–Emerald.
ι	3.5–9	255	50	Orange–Yellow.
Σ 1984	6.2–8.4	6	273.8	
Σ 2604	6.5–8.7	27	184.6	
Σ 2573	6.2–8.5	18	29	A striking object.
Σ 2348	6–8	25	272.7	Yellow–Blue.
μ	5–5	3	205	Both White.
Σ 2277	6.3–8.2	28	117	In Hercules.

Note Tuttle's Variable Nebula 4415.

According to Flammarion, omicron Draconis is an optical double, that is, two stars which, being nearly in the same line of sight, appear to be side by side, although one may be far more distant than the other.

One of the components of μ has a 13 mag. companion. μ is therefore really a triple.

DRACO

Polaris
URSA MINOR
Σ 123
Σ 1984
Σ 2277
Hercules
Σ 234
Σ 2323
Σ 2004
Σ 2573
40,41
4415

LYRA

LYRA (lī′-ra)—THE LYRE (Face East)

LOCATION—The constellation Lyra, throughout the summer, is high up the eastern sky, almost in the zenith in the early evening. It may be easily identified because of the brilliant Vega, of the first magnitude, the third brightest star seen in this latitude.

The six bright stars in Lyra form an equilateral triangle on one corner of a parallelogram. See the Diagram. Lyra is located between the constellations Hercules and Cygnus, and rises in the northeast in the early evening about May 1st. It is in the zenith at 8 P.M. on September 1st.

Mythology

> The Lyre whose strings give music audible
> To holy ears.
>
> LOWELL.

According to the ancient legend, Lyra represents the instrument which Apollo or Mercury gave to Orpheus. It is related that Orpheus, whose magic music charmed all, and even inanimate nature, married the beautiful nymph Eurydice. On her death Pluto took pity on the grief-stricken Orpheus, and permitted him to carry Eurydice from the place of departed spirits, but charged him that he should not look at her until he had emerged from the shades of darkness. Orpheus was thus able to win his loved one again, but forgetting Pluto's admonition, looked back at Eurydice and immediately she vanished, and he was never able to see her again.

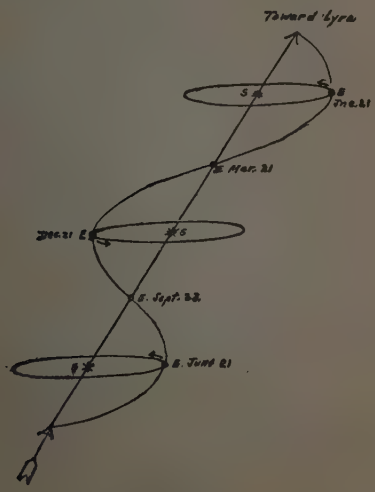
LYRA

After his death, Jupiter placed his magic Harp in the sky.

In Bohemia, Lyra was called "the Fiddle in the Sky," and the ancient Britons knew it as "King Arthur's Harp."

Space does not permit of further reference to the many myths relating to this beautiful constellation.

Lyra is of special interest as it is in this direction that the sun is bearing the earth and all the planets at the rate of twelve miles a second. It is, therefore, our goal, celestially speaking, and the star Vega beckons us on. We move toward the star at the rate of 378 million miles annually.



Annual motion of Earth through space as it accompanies the Sun toward Lyra at the rate of 12 miles a second.

For the Naked Eye and Field Glass

Vega was the first star to be photographed, in 1850. It is visible at some hour of the night throughout the year. It has been called "the Arc-light of the Sky." Its light has the bluish-white hue that suggests the brilliance of a diamond. The spectroscope reveals that Vega is a star about midway, according to the giant-dwarf theory, in the evolutionary scale.

Vega is fifty times brighter than the sun, and its diameter is about two and one half times that of the sun. Parallax determinations differ. The mean of four authoritative measures gives 26 light years as the distance that Vega is from us.

Vega is celebrated for the fact that, due to the Precession of the Equinoxes, it has once been, and will again in 12,000 years be the Pole star. Vega is approaching at the rate of 8.5 miles a second. It has a small companion star of the 11th magnitude. The heat that we receive from Vega has been measured, and amounts to that received from a candle eight and three-quarters miles away.

The double stars ϵ, δ, and ζ Lyræ can be separated with a field glass. The first is a double double for a telescope. (See diagram p. 75.)

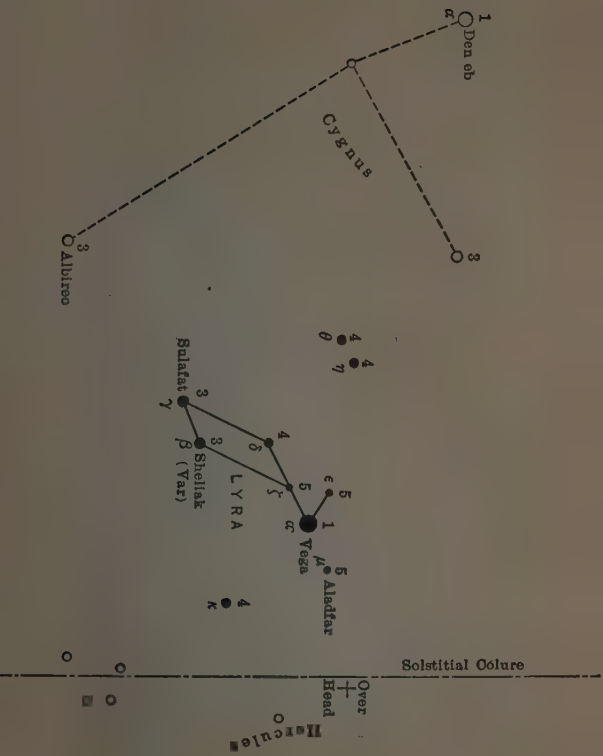
A sweep with an opera glass along the line from γ to β Lyræ is well worth while.

β Lyræ is a remarkable Variable star of great interest to astronomers. *Its variations in light can be observed with the naked eye*, and the phenomenon should be of interest to all who study the heavens.

The star's light changes from 3.4 magnitude to 4.5 magnitude in 12.9 days. At times it is brighter than gamma, and at minimum fainter. It is a spectroscopic double, and we have been able to determine the size of the two bodies and their shapes. The larger is 31 million miles in diameter, the smaller 24 million miles. The distance between their centers is 30 million miles. The mass of the larger is 21 times the sun's mass, the mass of the smaller 10 times.

Continued on page 162.)

LYRA



Den eb
Cygnus
Albireo
Sulafat
Sheliak
(Var)
LYRA
Vega
Aladfar
Solstitial Colure
Over
Head
Hercules

Professor Mitchell discovered that the star γ Lyræ was a spectroscopic binary. For details concerning the famous meteor shower, "the Lyrids," see chapter on meteors.

For the Telescope

For its size Lyra is one of the most remarkable of all the constellations for the telescopist. It has rich fields and many remarkable objects to observe. The following double stars are a few out of the many in the constellation:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ϵ	5–5	207	173	The noted double double. A marvelous object. Field glass double.
	ϵ^1 5–6	3	15	
	ϵ^2 5–5	2	133	
ζ	4.3–6	44	149	Topaz–Green. Field glass double.
β	4–7–8–11	45	150	A multiple star.
		65	320	
		85	20	
η	4.8–8	28	84	A fine field.
θ	5–10	101	70	Yellow–Blue.

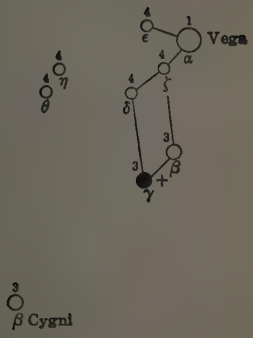
The "+" marks the location of the famous "Ring Nebula," a wonderful sight in our largest telescopes. A perfect ring of nebulosity, in the center of which gleams a 15th magnitude star. It can be seen in a 3-inch telescope, and appears as a faint and misty oval patch of light about the size of the planet Jupiter. The nebula is the best example of a planetary nebula in the heavens.

ϵ Lyræ, the renowned double double, is a test star for the eyesight. If you can split the pair without optical aid you have excellent sight.

According to Professor Russell, the period of the closer pairs must be many centuries in length, and that of the wider pair several hundred thousand years. The brightest of the four stars is a spectroscopic binary.

δ Lyræ is a wide double, easy for a field glass. Magnitudes 4.5–5.5. Distance 750″. The field about this star is glorious for low powers.

LYRA



CYGNUS

CYGNUS (sig′-nus)—THE SWAN, OR NORTHERN CROSS (Face East)

LOCATION.—Deneb, the brightest star in the constellation Cygnus, a star of 1.3 magnitude, marks the top of the Cross. It is a little over twenty degrees east of the brilliant Vega in Lyra. Deneb forms a triangle with Vega and Altair in Aquila, the latter being at the apex of this triangle, about thirty-five degrees from Deneb and Vega.

β Cygni marks the base of the Cross. A line drawn from Vega to Altair almost touches it.

The Cross is almost wholly in the Milky Way and rises lying on its side. It is a perfect Cross, and a beautiful figure.

Mythology

Yonder goes Cygnus the Swan, flying Southward.

There are various legends relating to this beautiful constellation. Some have thought that Cygnus represents Orpheus, who was changed into a Swan at his death and placed near his magic harp (Lyra) in the sky.

Another story relates that this is the Swan into which Jupiter changed himself when, unknown, he visited Leda, wife of Tyndarus, King of Sparta. Again, we are told that the constellation represents Cygnus, son of the King of the Ligurians, who was grief stricken at the death of his friend Phaëthon. Apollo took pity on him, turned him into a Swan, and placed him among the stars.

The Arabs knew this constellation as "the Flying Eagle," and the Greeks called it "the Bird."

The Cross is seen to best advantage in Winter, as it then assumes an upright position. On Christmas eve, at nine o'clock, it stands outlined against the western sky, a starry symbol of the Christian faith, a sign of promise from the realm beyond.

For the Naked Eye and Field Glass

The star 61 Cygni has an interesting history. It was the first star whose distance was measured. In October, 1838, Bessel published his announcement of the distance of this star as 10.3 light years. In 1842–43, the observation was confirmed by Peters at Pulkowa. Later determinations have increased this distance to 10.5 light years. At this distance the sun would look about as bright as the Pole star now does to us.

Three hundred and thirty photographs were taken of this star in 1886–7. These furnished material for 30,000 measurements.

For many years 61 Cygni was thought to be the nearest star to us. Now it ranks fifth in order of distance of the stars visible to the naked eye in the northern hemisphere.

61 Cygni is a double star of the sixth magnitude and just visible to the naked eye. The components, neither of which can be one-tenth as bright as our sun, are in slow relative motion, indicating that they are really moving in a vast orbit whose circuit, according to Professor Russell, may occupy a thousand years or more.

The Milky Way separates into two great parallel branches in Cygnus. Novæ appeared in this constellation in 1600, 1876, and 1920.

(*Continued on page 166.*)

For the Naked Eye and Field Glass—*Continued*

Sweep with opera glass or binoculars over the Milky Way in this region, particularly on a line from γ to β Cygni. It is a glorious field. Note the swarms of suns and clusters, and the occasional dark gaps.

The star o^2 Cygni is an attractive double in a field glass.

If you have a powerful binocular and hold it steadily you may be able to separate beta Cygni, one of the finest doubles in the heavens.

Cygnus contains an unusual number of deeply colored stars, and Variable Stars.

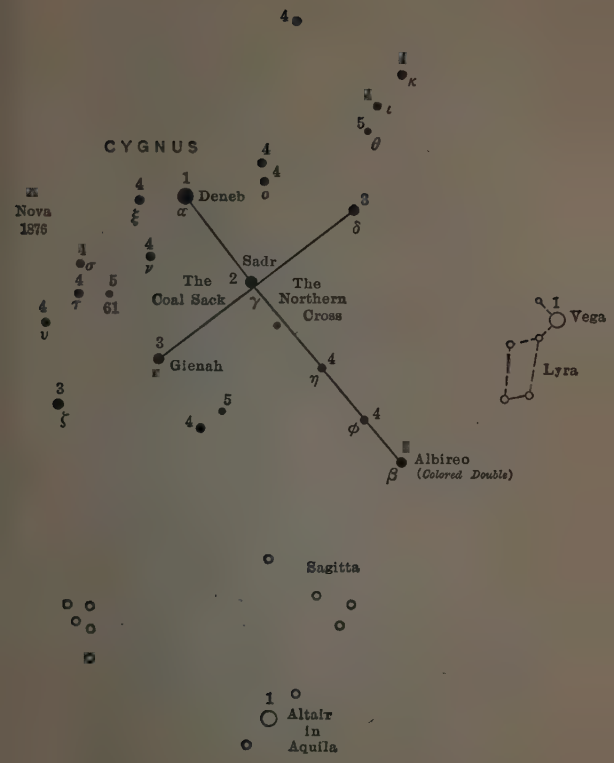
The location of one of the so-called "Coal Sacks" in the Milky Way is indicated on the Chart. These dark areas are now known to be clouds of cosmic matter that obstruct our view of the more remote stars.

Herschel counted 331,000 stars in an area of only five degrees in Cygnus.

This region is perhaps richer in stars than any similar portion of the sky. An opera glass will reveal many of its beauties.

The star Deneb, alpha Cygni, has a proper motion of 12 miles a second. An absolute parallax determination by Professor Mitchell gives 650 light years as its distance from our system. The star is of the same general type as the sun, and it is approaching the earth at the rate of 2 miles a second. It is now calculated that its actual luminosity exceeds the sun ten thousand times, and that eventually it will be so near as to outshine for several years every visible star.

CYGNUS


CYGNUS
Nova 1876
Deneb
Sadr
The Coal Sack
The Northern Cross
Gienah
Albireo
(Colored Double)
Vega
Lyra
Sagitta
Altair in Aquila

For the Telescope

Webb says of this region: "Its low-powered fields are overpowering in magnificence." To sweep over this region, even with an opera glass, is a delight.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
β	3.2–5.4	34	55	Yellow-Blue. Very fine.
52	4–9	6	60	Yellow-Blue.
17	5–8	26	73	Red-Blue. In fine field.
o^2	4–7.5	107	174	Orange-Blue. Field glass double.
	4–5.5	358	324	Double double.
ψ	5–7.5	3	184	White-Lilac.
61	5.6–6.3	23	127	
59	4.7–9	20	352	
μ	5–6–7.5–12	2.4	125	Multiple Star.
		208	56	
		15	264	
16	5.5–5.5	37	136	
26	5.3–8.5	41	146	Yellow-Blue.
48	6–6	178	174	
Σ 2486	6–6.5	10	224	
Σ 2578	6.5–7.5	15	127	
3	6–6	54	5	

Observe with a low power the wonderful star stream about the star γ. The "+" marks the location of the famous Dumbbell Nebula, M 27, in Vulpecula. Use low power.

Many consider beta Cygni the finest double star in the sky. Its contrasting colors, gold and blue, are very beautiful.

Two marvelous diffused nebulæ are located in Cygnus, but unfortunately they are beyond the range of small telescopes. Long time exposures with the aid of the largest telescopes have revealed the rare and wonderful beauty of these remote objects.

Deneb
α
γ
δ
ε
ζ
η
θ
ι
κ
λ
μ
ν
ξ
ο
π
ρ
σ
τ
υ
φ
χ
ψ
ω
Albireo
β
VULPECULA
M 27
κ Pegasi
μ
ζ
61
52
49
43
41
17
19
26
30
2578
2486

AQUILA

AQUILA (ak′-wi-la)—THE EAGLE (Face Southeast)

LOCATION. Half-way up the sky, in the Milky Way, note three stars in a line, a bright star flanked by two fainter stars. The brilliant star is Altair, in the constellation Aquila. It forms with Vega in the Lyre, and Deneb in the constellation Cygnus, an isosceles triangle. Altair lies at the apex of this triangle about 35 degrees from Vega and Deneb.

This is a double constellation composed of Aquila and Antinoüs. The latter only contains a few faint stars and is seldom referred to.

Mythology

> Aquila is next
> Divides the ether with her ardent wing
> Beneath the Swan, not far from Pegasus,
> Poetic Eagle.

The history of the constellation Aquila dates back to the earliest times, but very little of interest in the way of myth and legend relating to it has come down to us.

The Summerian-Akkadian Eagle was "Alula" (the great spirit) the symbol of the noontide sun. On a Euphratean uranographic stone of about 1200 B.C. there is a bird figured which is supposed to represent this constellation.

There is a close connection between the constellations Aquila and Aquarius, as they are both supposed to relate to Ganymede, the Cup Bearer of the gods. It is said that an eagle, the bird of Zeus, bore Ganymede aloft in its talons to his place in the sky.

AQUILA

Through all the ages Aquila has been known as a bird of prey, bearing the titles, "Eagle of the Winds" and "Soaring Eagle." Just as in the region of the sky around Aquarius we find aquatic creatures, so, here in this part of the heavens, we find the birds, the Swan, the Falling Eagle, Lyra, and the Swooping Eagle, Aquila.

The Persians, Hebrews, Arabs, Greeks, and Latins all knew this constellation as "the Eagle."

For the Naked Eye and Field Glass

In A.D. 389, a wonderful Nova or new star flashed out near Altair that equalled Venus in brightness, and vanished in three weeks time.

On the night of June 8th, 1918, another beautiful Nova blazed forth in the constellation Aquila, about seven degrees northwest of λ Aquilæ. See Chart. When first seen it was brighter than Altair and rivaled Vega in brilliance, the brightest Nova that had appeared in 300 years. The star rapidly waned in brilliance, and at the present writing is between 11.0 and 12.0 magnitude. We do not know as yet how to account for the sudden appearance of these brilliant stars. The phenomenon is probably due to a collision of heavenly bodies, or an explosion of a faint star.

The feature of the constellation is the beautiful first magnitude star Altair. This star rises eight degrees north of the exact eastern point on the horizon in the early evening about the middle of June, and sets during the early evening hours about the middle of December, so that it is visible all summer. With its two attendant stars, one on either hand, it presents a charming appearance. It culminates at 9 P.M. September 1st.

(Continued on page 172.)

For the Naked Eye and Field Glass—*Continued*

Altair is a star of the Sirian type, sixteen light years distant and is approaching us at the rate of twelve miles a second. It is a comparatively near neighbor of ours, and, actually only some nine times as bright as our sun and probably three times as bright per square mile, which makes its diameter one-half as great again as our sun's.

Altair, with its two companion stars Beta and Gamma Aquilæ, constitute the so-called "Family of Aquila." The line joining these stars is five degrees in length and makes an excellent yard stick.

There is an interesting short period Variable Star in Aquila, namely η Aquilæ. It changes from 3.5 magnitude to 4.7 and back again within a period of seven days, four hours, and twelve minutes. Remaining at maximum brilliance for forty hours, then gradually growing fainter for sixty-six hours. It remains at minimum brilliance for thirty hours, and then slowly regains its original brightness. It is a Cepheid Variable, that interesting class of stars which have enabled Professor Shapley to plumb the depths of the universe.

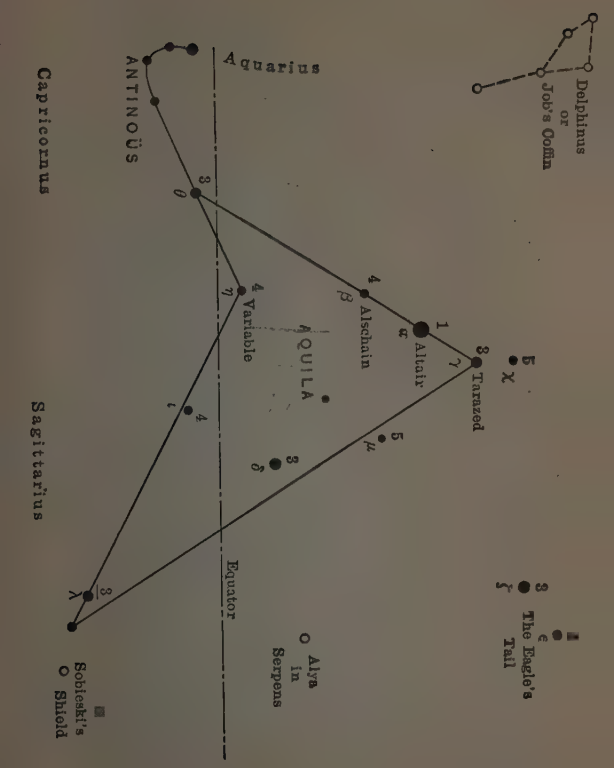
Observe with a field glass the star cluster 4440 (*See Telescope Chart*), a beautiful object consisting of stars of the ninth to the twelfth magnitude.

Another fine cluster, to be observed with a field glass, is in Sobieski's Shield, a small asterism west of λ Aquilæ. A little southwest of λ is a fourth magnitude star. The cluster is west of this star at about the distance separating α and β Aquilæ.

The variable star R (*see Telescope Chart*) can be picked up with a field glass at, or near, its maximum, 6.5.

The radiant point of the Aquilids, the meteor shower visible from June 7th to August 12th, is located about five degrees east of Altair.

AQUILA



Delphinus or Job's Coffin
Aquarius
ANTINOÜS
Capricornus
Sagittarius
Variable
Alschain
Altair
Tarazed
AQUILA
Equator
Alya in Serpens
The Eagle's Tail
Sobieski's Shield

For the Telescope

The chart indicates the position of the many fine double stars in this constellation listed below:

Double Star	*Magnitud*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
57	5–6	36	170	Yellow–Green. A fine double.
15	5.5–7.5	35	206	White–Lilac.
5	6–7	13	121	White–Bluish.
28	6–8	60	175	
11	5.7–8.2	18	242	Optical double.
Σ 2644	6–7	3	208	Primary bluish white.
Σ 2654	6.2–7.7	14	234	
Σ 2446	6–8	10	154	
Σ 2628	6–8	4	349	Yellow–Purple.

Altair has a tenth magnitude companion at a distance of 152″, angle 322°.

R denotes the position of a long period Variable star that fluctuates in light from a 6.5 magnitude star at maximum, to a 11.0 magnitude star at minimum, in a period of 351 days.

Struve gives white as the color of both of the stars in the double 57.

AQUILA

Altair
α
β
γ
δ
η
θ
λ
ζ
π
φ
Σ 2628
Σ 2644
Σ 2654
Σ 178
Σ 2446
4440
R
θ Serpentis
Nova 1918

DELPHINUS

DELPHINUS (del-fi′-nus)—THE DOLPHIN, OR JOB'S COFFIN (Face Southeast)

LOCATION.—The little group of five faint stars, forming the constellation Delphinus, is located about ten degrees northeast of Altair, in Aquila. A line drawn from Vega in Lyra to β Cygni, prolonged about twenty degrees, indicates the fourth magnitude star ϵ in the tail of the Dolphin.

Delphinus is also called "Job's Coffin."

SAGITTA

SAGITTA (sā-jit′-a)—THE ARROW (Face Southeast)

LOCATION.—The dainty little constellation of the Arrow lies close to Delphinus, and about midway between β Cygni and Altair in Aquila, in the Milky Way.

It is composed of five faint stars, and is of interest because it really looks like an arrow.

Webb says of it: "A little asterism, of much greater antiquity than might have been supposed from its size and the smallness of its components. Sweeping here is magnificent."

Mythology

DELPHINUS

The Dolphin small of sight floats
O'er the Goat.

ARATOS.

The popular legend relating to the Dolphin associates it with Arion, and is as follows: Arion, a native of Lesbos, was a famous poet and musician. He embarked on a ship to return home. The sailors, envious of his fame, determined to kill him. Arion became aware of the plot and requested that his lute be given him. His request was granted, and the magic of his music attracted around the ship a school of Dolphins. Arion leaped on the back of one of them, and the creature bore him safely ashore. He denounced the sailors who, on their arrival in port, were executed. Neptune, pleased with the Dolphin for the service rendered Arion, honored it with a place among the stars.

SAGITTA

According to one authority, this is the Arrow with which Apollo killed the Cyclops. We are also told that it was one of the arrows used by Hercules to kill the hideous vulture that was gnawing at the vitals of Prometheus as he was chained to a rock on the summit of Mount Caucasus.

Sagitta has also been regarded as Cupid's Arrow.

For the Naked Eye and Field Glass

DELPHINUS AND SAGITTA

The peculiar star names given alpha and beta Delphini, spell backwards the name of the astronomer Piazzi's assistant, Nicholaus Venator.

In Greece, the Dolphin was regarded as "the Sacred Fish," the sky emblem of philanthropy. The Arabs called this group "the Riding Camel." The Chinese knew it as "the Gourd."

Sweep over the region about Delphinus and Sagitta with an opera glass. It is an attractive field.

(*For the Telescope, see p. 180.*)

DELPHINUS AND SAGITTA

DELPHINUS

For the telescopist the following double stars are given, out of the many in the constellation.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	4–9.5	35	278	
γ	4.5–5.5	10	269	Yellow–Bluish green. A beautiful object.
Σ 2678	6.1–8.2	4	349	In Aquila.

θ Delphini lies in a rich field.

There is an attractive pair of stars in the field with ε Delphini.

Just southwest of ζ Delphini is a triple star. Its components are of the 7.5 magnitude.

Delphinus contains a large number of long period Variable Stars.

SAGITTA

The following double stars will interest telescopists:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ε	6–7.8	92	81	
θ	6–8–7	11–70	326–226	Triple.
ζ	5.7–8.8	8.8	312	Green–Blue.

Note 13, a sixth magnitude star with a seventh magnitude companion, 340″ distant, angle 13°.

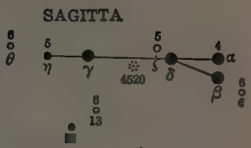
Alpha and beta are both wide doubles.

Fifteen commands a fine group. A few minutes of arc north of it is a beautiful sapphire blue star.

η lies in a rich region. A circle around it of thirty or forty minute radius will include several attractive pairs of stars.

Webb describes the cluster 4520 as an interesting specimen of the process of nebular resolution. About one degree south of it is a beautiful low power field containing pairs and triples.

DELPHINUS AND SAGITTA



SAGITTARIUS

SAGITTARIUS (saj-i-ta′-ri-us)—THE ARCHER
(Face South)

LOCATION.—This conspicuous zodiacal constellation is situated on the ecliptic, between the constellations Capricornus to the east and Scorpius to the west. A line drawn from Deneb in Cygnus, to Altair in Aquila, prolonged an equal distance, terminates in Sagittarius, about ten degrees east of its distinguishing feature, the "Milk Dipper."

Sagittarius is about south in a fine position for observation during the month of July, between the hours of 9:30 and 11:00 P.M.

Mythology

Midst golden stars he stands refulgent now
And thrusts the Scorpion with his bended bow.

OVID.

The constellations Sagittarius and Scorpius are closely associated, for the Archer has from ancient times been depicted as aiming his shaft at the heart of the Scorpion.

According to the Greek legend, Sagittarius represented the celebrated Centaur, Chiron, a figure half-man, half-horse. He was the son of Saturn and Philyra, and is said to have changed himself into a horse in order to escape from his jealous wife, Rhea.

Chiron was famous in his day for his knowledge of medicine, music, and marksmanship. He is said to have taught mankind the use of plants and herbs for medicinal purposes. He was a noted educator, and numbered among his pupils such famous personages as Apollo, Hercules, Æsculapius, Achilles, Jason, and Æneas.

Mythology ascribes his death to a scratch which he received from a poisoned arrow. Jupiter pitied his sufferings and honored him with a place among the stars.

Sagittarius is sometimes called "the Bull Killer," which signifies that, when the stars in Sagittarius rise in the east, they seem to drive the stars of Taurus, the Bull, below the horizon.

For the Naked Eye and Field Glass

Observe with opera or field glasses the dark lanes and areas in the Milky Way in this constellation, especially near the stars γ and δ Sagittarii. These are now known to be luminous clouds of obscuring matter, like the "Coal Sacks" in Cygnus.

Note particularly the clusters M 8 and M 24.

On a clear moonless night the little asterism, known as "Corona Australis," the Southern Crown, can be seen about ten degrees south of the bowl of the "Milk Dipper." It is on the meridian at 9 P.M., August 13th.

The bow of the Archer, represented by a curved group of three fairly bright stars, is marked by the stars λ, δ, and ϵ Sagittarii.

γ Sagittarii, a star of the third magnitude, marks the tip of the drawn arrow pointed directly at the ruddy star Antares in the heart of the Scorpion.

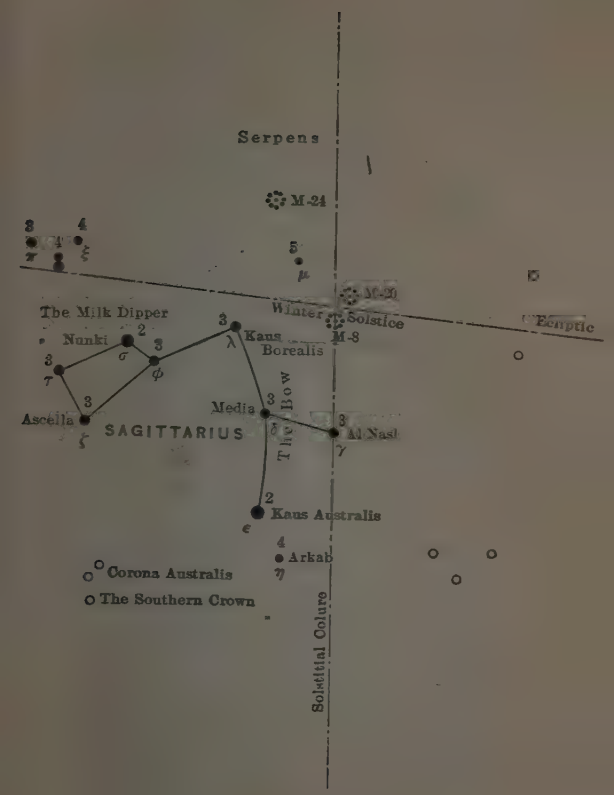
The stars, ϕ and ζ in the "Milk Dipper," are moving in opposite directions in the sky. This motion will, in the course of thousands of years, distort the figure to such an extent as to render the famous figure of the "Milk Dipper" no longer recognizable.

The stars λ, ϵ, and γ Sagittarii are rapidly moving in parallel lines in a southwesterly direction. The star δ Sagittarii, which is the middle star in the bow, has a small proper motion toward the southeast.

Shapley has recently announced that the center of the great Galactic system is located in this region of the sky.

The planet Saturn will be in this constellation from 1929 to 1932 inclusive. Compare its color with that of Antares in Scorpio a few degrees westward.

SAGITTARIUS



For the Telescope

Owing to the presence of the Milky Way in this constellation, the region offers many beautiful clusters for the telescopist to observe. To sweep over this part of the sky, with low powers, is to derive much pleasure.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
54	6–7.5	45	42	Yellow–Blue.
μ	3.5–9.5–10	48	312	A multiple star.
		55	114	
Σ 2425	6–9.5	12	257	In Sobieski's Shield.
Σ 2406	7.2–8	12	219	In Sobieski's Shield. A beautiful double.

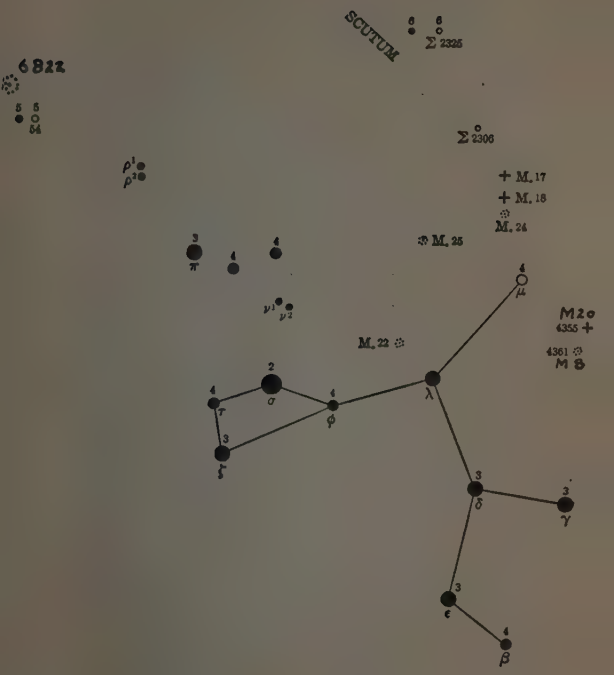
Sagittarius contains one of the most remarkable objects in the heavens—a marvellous star cluster. Unfortunately it requires a powerful telescope to observe it. As many as 15 Cepheid Variables have been discovered in this cluster. They vary in brightness about one magnitude, and their periods range from 64 to 12 days. At maximum they are of the 17th to the 19th magnitude. The stars with the longest periods are brightest. Professor Russell estimates that the brightest stars in the cluster are about thirty thousand times as bright as the sun. The total number of stars in the system must run well over a million. The most astounding fact of all is that the calculated distance of the cluster from us is 700,000 light years.

There are many fine clusters in this region that claim attention. Note especially M 22, M 24, M 25. Messier 22 is at a distance of 27,000 light years and must contain 50,000 stars. This cluster is visible to the naked eye, and has been known since 1665. Sweep over the Milky Way in this region of the sky with a field or opera glass.

Observe the so-called "Trifid Nebula" 4355 (M 20), also M 17, known as "the Horse-shoe Nebula," one of the few nebulæ that can be observed with comparatively low optical power.

M 18 is in a glorious field.

About 1¼° south of λ Sagittarii is a fine seventh magnitude triangle of stars.


SCUTUM
6822
Σ 2325
Σ 2306
M. 17
M. 18
M. 24
M. 25
M. 22
M20
4355
4361
M 8
π
ρ¹
ρ²
ν¹
ν²
σ
τ
ζ
φ
λ
μ
δ
γ
ε
β

OPHIUCHUS AND SERPENS

OPHIUCHUS (of-i-ū′-kus), THE SERPENT BEARER, AND SERPENS, THE SERPENT (Face Southwest)

LOCATION.—A line drawn from ϵ Delphini to γ Aquilæ, prolonged about thirty degrees, strikes alpha Ophiuchi, a second magnitude star in the head of the giant Ophiuchus, the brightest star in this large constellation.

Alpha Ophiuchi, Altair in Aquila, and Vega in Lyra form an isosceles triangle. Altair is at the apex.

Two constellations are here combined and their stars intermingle.

Alpha Herculis, marking the head of the Hero, lies just west of alpha Ophiuchi.

Equally distant southeast and southwest of alpha Ophiuchi are to be seen two pairs of stars which mark the shoulders of the giant. His feet rest on the Scorpion, just above the red first magnitude star Antares in the heart of the Scorpion.

The head of the Serpent is marked by a group of faint stars in the form of an "X", just below the Crown.

Mythology

Thee, Serpentarius, we behold distinct
With seventy four refulgent stars.

EUDOSIA.

The giant Ophiuchus is represented on the ancient atlases as standing on the Scorpion, and holding in his hands across his knees a writhing serpent, which the constellation Serpens represents. "Serpentarius" is another name for the giant.

OPHIUCHUS AND SERPENS

According to the Greek legend, Ophiuchus represents the renowned physician Æsculapius, the inventor and god of medicine, with whose worship serpents were always associated.

Æsculapius is said to have been educated either by his father Apollo, or Chiron the Centaur. He was so skillful in his profession that it is said he could even restore the dead to life. This achievement so alarmed Pluto, who reigned over the nether world, that he persuaded Zeus to remove Æsculapius from the earth and place him among the stars.

In the middle ages, Ophiuchus was sometimes regarded as representing Moses with the Brazen Serpent. It is also claimed that Ophiuchus represents Laocoön, a son of Antenor. To punish him for thrusting a spear through the famous wooden horse at Troy, two serpents were sent to attack him, and strangled him in their folds together with his two sons who came to his rescue.

There is a noted piece of statuary in the Vatican Museum depicting this tragedy.

The constellation was known to the ancients fully 1200 B.C.

For the Naked Eye and Field Glass

Sweep with a field or opera glass for a cluster of 8th magnitude stars near β Ophiuchi. The star is in the right shoulder of the giant.

1604 indicates the spot where, in that year, a famous Nova appeared known as "Kepler's Star." At maximum it rivalled Venus in brilliance.

Observe the small asterism, "The Bull of Poniatowski," just east of γ Ophiuchi. It is an attractive group of four stars. The star 70 can hardly be called a near neighbor. Its distance has been estimated at 120 quadrillions of miles.

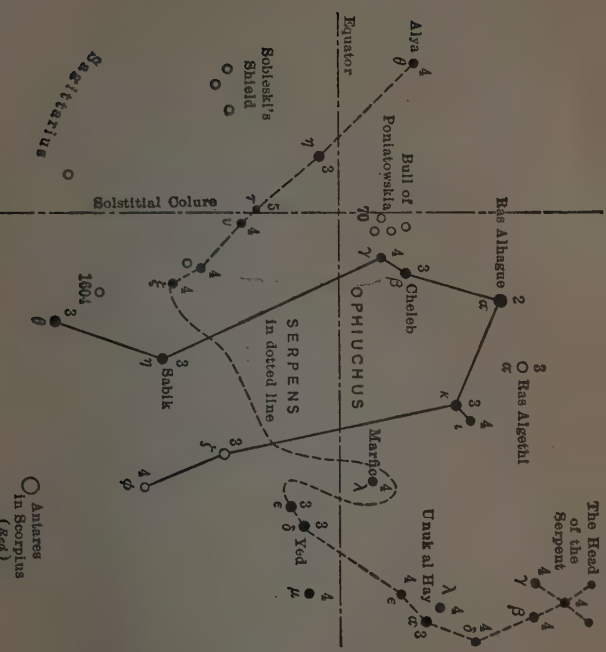
The dark regions of the Milky Way, conspicuous objects in this constellation, are known to be clouds of cosmic matter that obstructs our view of the more remote stars. Professor Bailey is of the opinion that the cloud near ρ Ophiuchi, discovered by Professor Barnard, obscures from our view no less than 10,000 stars or more to a square degree, taking into account stars we are able to photograph.

According to Professor Russell, these cloud masses are approximately 400 light years distant. They must be at least 50 light years long, and several light years wide.

The constellation Ophiuchus contains a remarkable star. It is known as "Barnard's Runaway Star" because of its extraordinary high proper motion. It was discovered by Professor Barnard in 1916.

The star is orange in color, and its magnitude is 10. It is situated just west of the fifth magnitude star 66 Ophiuchi, which is the uppermost star in the Bull of Poniatowski. This star has a proper motion of 162 miles a second. It is approaching us at the rate of 73 miles a second, and is 6.1 light years distant, the nearest star to us in the northern hemisphere, and the third nearest of all the stars. The star is rushing northward, a moon's breadth, in 190 years. It is a dwarf star of the M type.

OPHIUCHUS AND SERPENS



For the Telescope

The star cluster 4083 (M 5) is an interesting object. According to Professor Shapley, it is 39,800 light years distant. With the exception of M 13, which is the great cluster in Hercules, it is the nearest of the northern globular clusters. Scores of the stars in this cluster are variables.

OPHIUCHUS

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
67	4–8	54	144	Yellow–Red or purple. Fine contrast.
36	6–6	4	43	Yellow–Red.
39	5.5–6	11	358	Yellow–Blue.
Σ 2166	5.7–7.4	27	283	White–Bluish.
61	5.5–5.8	20	94	
53	5.6–7.3	41	191	
19	6–9.3	22	93	
70	4.3–6	4	148	Yellow–Red.
ρ	6–6	4	2	Fine close pair. Yellow–Blue.

Webb says that the region near the Nova 1848 should be closely observed.

SERPENS

In dotted line on the Diagram.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
δ	3–4	3	197	Both white. A fine object.
θ	4–4.2	21	104	Both yellow. Lies in rich field.
ν	4.5–9	50	31	Green–Lilac.
β	3–9	30	265	Blue–Yellow.
5	5–10	10	41	
Σ 2342	6–8	26	120	
Σ 1931	6.2–7.6	13	172	

70 Ophiuchi, and ν Serpentis are colored Variables.

Observe the double star *m* Herculis. Magnitudes 6–8; Distance 69″; Angle 230°.

OPHIUCHUS AND SERPENS

SCORPIUS

SCORPIUS (skôr'-pi-us)—THE SCORPION (Face South)

LOCATION.—The constellation Scorpius lies just south of Ophiuchus, the Serpent Bearer. It is a conspicuous zodiacal constellation, and the resemblance to a scorpion traced out in stars is not difficult to see.

The red first magnitude star Antares, the brightest star in the constellation, is in the heart of the Scorpion. The arrow aimed by Sagittarius, the Archer, points directly to it.

The constellation is situated on the ecliptic between the constellations Sagittarius to the east, and Libra to the west.

Mythology

> There is a place above where Scorpio bent
> In tail and arms surround a vast extent.
>
> OVID.

The constellation Scorpius is mentioned by all the early writers on Astronomy. It is supposed to have received its name from the fact that, when the sun entered this sign in ancient times, sickness was prevalent in Egypt. The old myths concerning Scorpius connect it with Orion, the Giant Hunter. The creature is said to have sprung out of the earth at the command of Juno, who, incensed at Orion's conceit, ordered the Scorpion to attack him. The Scorpion stung Orion in the foot, causing his death. Subsequently, Orion and the Scorpion were both honored with a place among the stars, but they were so placed that they never appear in the heavens at the same time.

The star name Antares, given to the brilliant star in Scorpius, means "the rival of Mars." Antares was one of the so-called "Royal Stars" of Persia 3000 years B.C. In China it was known as "the Fire Star."

A record of a lunar occultation of beta Scorpii in the year 295 B.C. is extant.

For the Naked Eye and Field Glass

According to several well known authorities, the stars in Scorpius belong to a great cluster at a distance of three or four hundred light years. This cluster is slowly approaching us at the rate of four miles a second.

The star ε Scorpii has the most rapid proper motion of the stars in the constellation. It is moving in a south-westerly direction, and probably nearer to us than any of the other stars in Scorpius.

The majority of the stars in Scorpius are between 180 and 400 light years distant. Some are possibly 1,000 light years away.

The feature of the constellation Scorpius is the star Antares, the rival of Mars. This star is a super-star, a giant among giants. The diameter of Antares was recently measured with the interferometer by Professor Pease at the Mt. Wilson Observatory. It was found to be 420 million miles in diameter. This is more than twice the extent of the earth's orbit.

According to Professor Russell, Antares is at least 3,000 times as bright as the sun, but gives out per square mile only one-eightieth as much light as the sun. The star is approximately 360 light years distant.

Antares rises at sunset June 1st, and is on the meridian at 9 P.M., July 11th.

(*Continued on page 196.*)

For the Naked Eye and Field Glass—*Continued*

Two or three degrees north of Antares is the spot where Coddington's Comet, C 1898, was discovered. It was the third comet to be discovered photographically.

A sweep over this region with opera or field glass will reveal many beautiful objects.

If the night is clear you can see the star cluster M 80 and the two clusters indicated on the diagram a short distance northeast of the star λ Scorpii; M 6 and M 7.

Herschel considered that the cluster 4173 (80 M) was the richest mass of stars in the heavens. On the eastern side of this cluster is a starless area, one of the so-called "Coal Sacks."

The star λ Scorpii is 360 light years distant, and must, according to Professor Russell, exceed the sun in light 2,000 times. Its spectrum is of the "Orion type." It is a brilliant white star, and intensely hot. Its temperature is probably from 20,000 to 30,000 degrees Centigrade, as against 6,000 degrees for the sun.

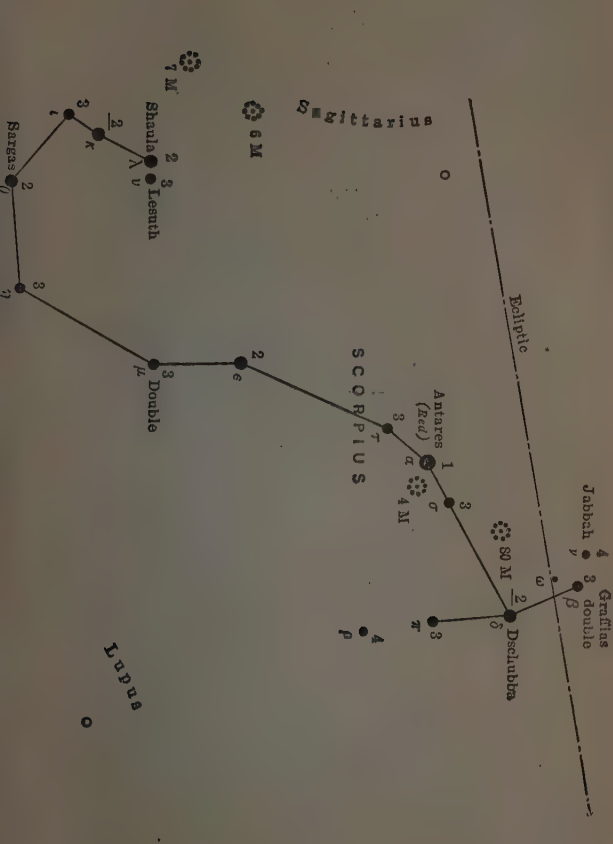
ν is a double for a field glass held steadily.

The star μ Scorpii is a fine naked eye double. It moves with a speed no less than 300 miles a second, in an orbit about six million miles across, the mass of the system being about 18 times that of the sun.

The curved tail of the Scorpion is marked by the two stars λ and υ Scorpii, a conspicuous pair.

Many Novæ, or temporary stars, have appeared in this region of the sky. The first one noted in astronomical annals appeared in Scorpius in 134 B.C.

The head of the Scorpion is marked by the three stars β, δ and π Scorpii to the west of Antares.


Sagittarius
Ecliptic
Jabbah
Graffias double
Dschubba
Antares (Red)
SCORPIUS
Lupus
Double
Lesuth
Shaula
Sargas
6 M
7 M
4 M
80 M

For the Telescope

The components of the double star ξ Scorpii revolve about their center of gravity in a period of 45 years. A little south of this star is the double star Σ 1999, M 7.5–8, D. 10″, A. 103°.

The vivid green companion of Antares is an interesting star. It is three seconds distant from its giant companion, and at an angle of 270 degrees. Its spectrum is of the Orion type, which means that it is an intensely hot star. Its real luminosity must be about fifty times that of the sun. The two stars probably form a binary system. They are moving together in space, and show traces of slow orbital motion. Proctor says that a larger glass than a four-inch is required to split the star.

The constellation Scorpius contains many attractive telescopic objects. The following double stars will be of interest to those possessing telescopes.

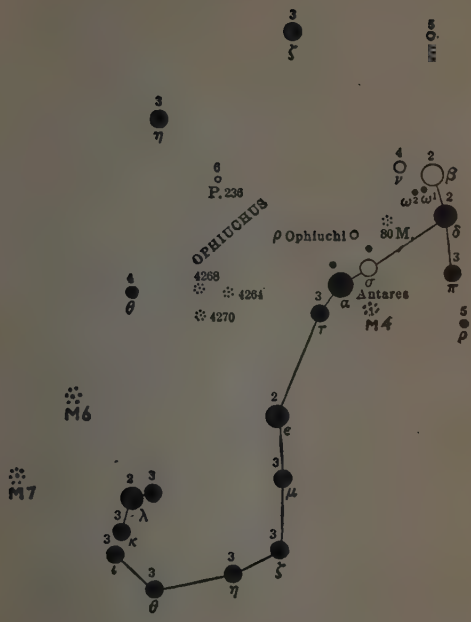
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
β	2.9–5	13	24	White–Bluish. Fine contrast.
ν	4–7	41	336	A multiple star. Field glass double.
σ	3–9	20	272	White–Blue.
ξ	4.6–7	7	65	White–Gray. A beautiful field.
P236	6.5–8	4	231	A fine pair.
ρ	6–6	4	2	In Ophiuchus.

The cluster 4264, in Ophiuchus, was discovered by Messier in 1764, and catalogued as a nebula. In 1784 Herschel proved it to be a globular cluster.

The cluster 4268 was discovered by Herschel. It is 2′ in diameter.

4270 is a fairly brilliant globular cluster followed by a faint nebula.

ν Scorpii is said to be the most beautiful quadruple star in the sky. A 3″ glass shows only two stars.


3
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P. 236
OPHIUCHUS
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LIBRA

LIBRA (lī′-bra)—THE SCALES (Face Southwest)

LOCATION.—Libra, an inconspicuous zodiacal constellation, is located between the constellations Virgo and Scorpius. Its two principal stars, alpha and beta Libræ, of the third magnitude, are a few degrees west of the Scorpion. See Diagram.

ι Libræ, a star of the fourth magnitude, is situated about twenty degrees northwest of Antares, the brilliant red star in the heart of the Scorpion.

A quadrilateral figure, formed by the four brightest stars in the constellation, outlined in the Diagram, will be of assistance in identifying Libra.

Mythology

Libra weighs in equal scales the year.
THOMSON.

The ancient Hebrews, and early inhabitants of India, regarded these stars as representing a celestial balance.

The Greeks combined this constellation with the Scorpion, and the stars in Libra marked the claws of the creature. Later, they believed that Libra represented Mochus, the inventor of weights and measures.

The title "Libra" for this constellation, we owe to the Romans. In the days of Julius Cæsar, Libra was regarded as the balance of Æstræa, the goddess of Justice, upon which the fate of mortals was weighed.

It is supposed that the figure of a balance in this region of the sky refers to the fact that, when the sun passes through this constellation, the days and nights are of equal length.

Virgil relates that the stars in Libra were held in high regard by husbandmen as they indicated the time of year for sowing their winter grain.

For the Naked Eye and Field Glass

Alpha Libræ has a 5.3 magnitude companion at a distance of 230″. Observe it with a field or opera glass.

Beta Libræ is the only naked eye star that is green in color. It is a wide double for a field glass, and is approaching our system at the rate of six miles a second. Early writers mention the brilliance of this star. Claudius Ptolemy gives it as equal to Antares. One of these two stars has possibly varied in light since ancient times.

For the Telescope

For the telescopist the following double stars are worthy of observation:

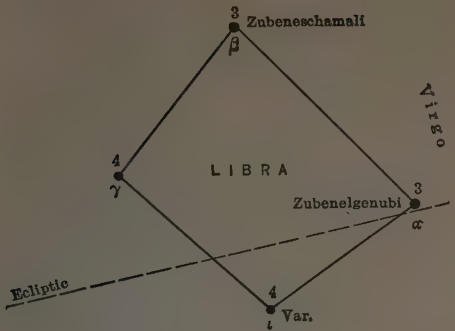
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ι	5.5–9.5	57	110	Yellow–Purple. Difficult for a 3 inch telescope.
P 212	6–7.5	15	293	
Σ 1962	6.3–6.4	12	187	A fine object.
H 4783	6–9	11	232	
54 Hydræ	6–7.5	9	129	

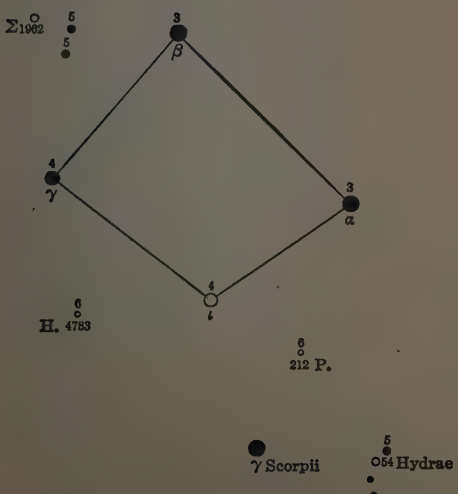
According to Professor Wilson, P 212 resembles the double 61 Cygni. Both stars have a large proper motion in the same direction.

Delta Libræ is a Variable Star of the Algol type. It was discovered by Schmidt in 1859. It has a period of two days and eight hours.

A line drawn from ι to β Libræ, prolonged a little beyond its length, locates the star cluster 4083 in Serpens, close to the fifth magnitude star 5 Serpentis.

LIBRA


3
Zubeneschamali
β
Virgo
4
γ
LIBRA
3
Zubenelgenubi
α
Ecliptic
4
ι
Var.


Σ1962
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ι
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H. 4783
6
212 P.
γ Scorpii
5
54 Hydrae

CORONA BOREALIS

CORONA BOREALIS (kō-rō′-nä bō-rē-a′-lis)—THE NORTHERN CROWN (Overhead)

LOCATION.—A line drawn from α Cygni to Vega, prolonged a little over forty degrees, terminates in the Crown. The constellation lies between the constellations Hercules and Boötes, and just above the diamond-shaped group in the head of the Serpent.

The Crown is composed of seven stars in the form of a semicircle, and the group bears a striking resemblance to the diadem its stars represent. The seven principal stars in the constellation are of the fourth magnitude, excepting alpha Coronæ, which bears the name "Gemma." This star is of the second magnitude, and known as "the Pearl of the Crown."

Gemma, sometimes called "Alphecca," forms with γ Boötes and Arcturus an isosceles triangle, the vertex of which is marked by the star Arcturus.

Mythology

> And midst the glittering symbols of the sky,
> The starry crown of Ariadne glides.
>
> APOLLONIUS RHODIUS.

The Crown, according to an ancient legend, commemorates the diadem presented to Ariadne by Bacchus. It is related that Theseus, son of the King of Athens, was confined in the famous labyrinth of Crete, a prey to the ferocious Minotaur, half man, half bull, that inhabited the place.

Each year the Athenians were compelled to offer the Minotaur as tribute a number of their young men and maidens. Theseus was one of this unfortunate number. He resolved to kill

the monster, and his loved one Ariadne gave him a sword and a spool of thread. Unwinding the thread as he penetrated the winding paths of the labyrinth, he came upon the monster and slew it, then retracing his steps with the aid of the thread he escaped from the place.

Although Theseus married Ariadne, later on he deserted her, but the gods in pity gave her a beautiful crown which on her death was placed in the sky, and we now behold Ariadne's Crown adorning the night skies of Summer.

The Shawnee Indians of our own country called this group of stars "the Celestial Sisters," and have an interesting legend respecting it, but lack of space does not permit of its inclusion here.

The Arabs imagined that they saw in this group of stars a dish, and their star name for alpha Coronæ, "Alphecca," means "the Bright one of the Dish."

For the Naked Eye and Field Glass

This beautiful coronet of stars is always a beautiful and alluring object to view with the naked eye or opera glass. For the field glass, observations of the irregular Variable Star R Coronæ are scientifically valuable. See paragraph in For the Telescope, p. 208.

Close to ϵ Coronæ a brilliant star suddenly appeared May 12, 1866. At maximum it was as bright as Polaris. It was known as "the Blaze Star." It was visible to the naked eye for only eight days, fading to the tenth magnitude, and then rising to the eighth magnitude where it still remains. It was found that it had been observed before by Argelander, and entered in his famous catalogue as a ninth magnitude star, so that it was recognized to be

(*Continued on page 206.*)

For the Naked Eye and Field Glass—*Continued*

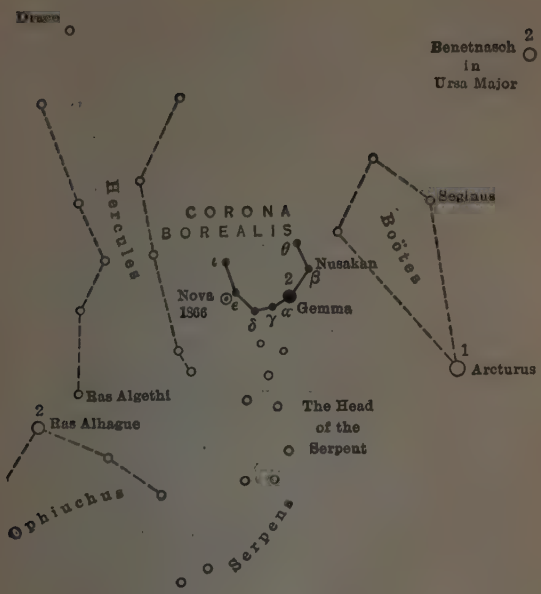
a remarkable Variable, but not a Nova in the true sense of the word. The star is now known as "T" Coronæ.

T Coronæ was the first temporary star subjected to examination by the spectroscope. Huggins detected in its spectrum the strong bright lines of hydrogen, which are characteristic of the type. The star is remarkable for the fact that it was located forty degrees from the Milky Way, whereas practically all Novæ lie close to the plane of the Galaxy. The star was brighter before the outburst of light than any other temporary star yet recorded. Moreover, the period of brightness was unusually short-lived, enduring but a few months, where other Novæ have often required years to return to their original states. The star is now between ten and fifteen times the sun's brightness.

α Coronæ, or Gemma, is in almost exactly the same condition, physically speaking, as our sun. According to Professor Russell, it belongs to a group of stars, which include Sirius and the five inner stars in "the Dipper," and this group is moving through our great star cloud. We are so near this moving group that its bright stars look to us widely separated in the sky, but after, say, tens of millions of years, they would be seen as a compact swarm. The shape of this moving cluster is remarkable in that it is very much flattened, or disc-shaped; its extreme diameter is about 110 light years, and its thickness only about eight light years. Its individual suns are all moving through space, in parallel paths, with a uniform speed of 18 miles a second. The distance of Gemma from the earth is approximately 61 light years, and its actual brightness 38 times that of the sun.

The grouping of the Crown is merely an effect of chance. No two of the seven stars are moving in the same direction, or at the same rate. α and β Coronæ are moving in opposite directions, and have nearly exchanged places in the past 50,000 years. At an equal interval in the future, they will be apparently three times as far apart as they are now, so that the constellation will bear no resemblance to its present aspect.

CORONA BOREALIS



Corona Borealis as it now appears

As the constellation will appear 108,000 years hence

For the Telescope

Webb cites sixteen double stars in this constellation, but only a partial list can be given here. The Chart indicates their location.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ζ	4–5	6	303	White–Blue or green.
σ	5–6	5	219	Great divergence as to colors. Binary. Period 350 years or more.
Σ 1964	6.8–7.3	15	86	

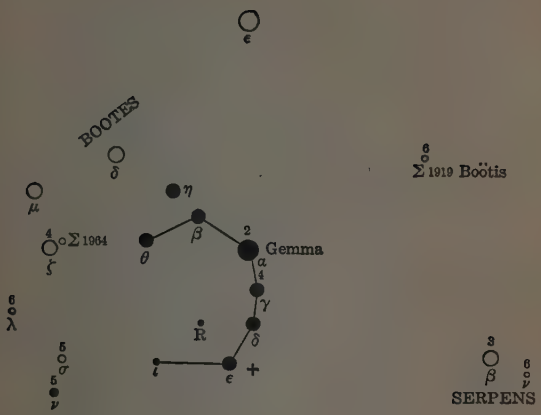
The + marks the spot where "the Blaze Star," referred to above, appeared in 1866.

"R" marks the location of a remarkable irregular Variable Star. It remains sometimes for as long as two years at 6.0 magnitude, just visible to the naked eye, then declines in brightness rapidly within the course of a few weeks to thirteenth magnitude or lower, and later slowly resuming its original brightness, presenting a baffling enigma. This star is being closely observed by the members of the American Association of Variable Star Observers.

η Coronæ is a splendid double star, but the pair are too close to be split by an aperture under five inches. Its period is 41.5 years, and three revolutions have been completed since its discovery by Herschel in 1781.

ν Coronæ is a fine wide double, visible to the naked eye. Both deep yellow with a sixth magnitude gray star following. 4.8–5.1; Distance 371″; Angle 165.6°. The two components are moving in opposite directions.

CORONA BOREALIS



HERCULES

HERCULES (her′-kū-lēz)—THE KNEELER (Overhead)

LOCATION.—A line drawn from either Vega in Lyra, or Altair in Aquila, to alpha Coronæ (Gemma), passes through the constellation Hercules.

The left foot of Hercules, marked by the fourth magnitude star ι Herculis, rests on the head of the Dragon in the north. The head of Hercules, marked by the third magnitude star alpha Herculis, nearly touches the head of the giant Ophiuchus.

Alpha Herculis, which bears the Arab name "Ras Algethi," is about 25 degrees southeast of Corona Borealis.

Alpha Herculis and alpha Ophiuchi are only five degrees apart.

The stars, ε ζ, η, and π Herculis, form a figure shaped like a keystone which serves to identify the constellation.

On a clear moonless night the obsolete asterism known as Cerberus, representing the three-headed dog which Hercules holds in his hand, can be seen.

Mythology

Hercules with flashing mace.

BRYANT.

There is a great deal of mystery concerning the origin of this constellation. It is one of the most ancient of the star groups.

We know that it was worshipped by the early Phœnicians as representing their god Melkarth. The Greeks knew it as "the Phantom," and "the Man upon his Knees."

For us, the constellation memorializes Hercules, the famous Theban hero of mythology, celebrated for his twelve labors which required the display of such prodigious valor and heroism.

The death of Hercules was a tragic affair. It is related that the hero, tortured by a tunic he had unwittingly put on, which proved to contain a deadly poison, climbed to the summit of Mt. Œta where he raised a funeral pyre, and reclining upon it, perished in the flames.

Jupiter, in pity, caused a cloud to descend which enveloped him, and carried the hero to a place among the stars, where he now shines honored for all time.

For the Naked Eye and Field Glass

Hercules occupies the region of the sky toward which the sun is bearing the earth and all the planets at the rate of twelve miles a second. Herschel and Argelander fixed on lambda Herculis as marking the sun's goal, or Apex of the Sun's Way. More recent determinations have fixed its position as near the brilliant star Vega in Lyra.

This region of the sky is remarkable for the fact that hardly any two stars are moving in the same direction, or at the same rate, and motions to the four cardinal points occur with an entire lack of uniformity, which is not true of stars in regions at right angles to this part of the sky. Professor Russell tells us that the reason for this apparent chaotic state of proper motion in this part of the sky is due to the motion of our system. (See p. 57.)

Alpha Herculis is a red star and a Variable, which changes irregularly in brightness from the third to the fourth magnitude. According to Professor Russell, alpha Herculis gives only about one-fifth as much light in proportion to its heat as most stars of its class, and hardly one-fiftieth as much as a white star like Vega. This indicates that its surface temperature must be much lower, perhaps 2400 *c.* degrees, as against 3000 *c.* degrees for an ordinary red star like Antares.

(Continued on next page.)

For the Naked Eye and Field Glass—*Continued*

The feature of the constellation Hercules is the great globular star cluster, 4320 M 13. It is located on a line between the stars η and ζ Herculis in the position indicated on the Diagram, two degrees south of η Herculis.

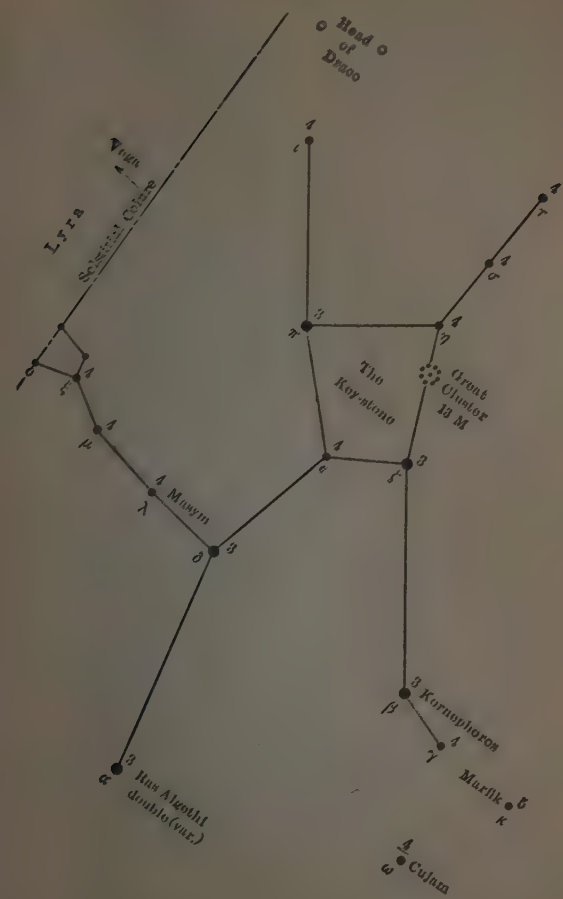
This magnificent object, the finest globular cluster in the northern hemisphere, is barely visible to the naked eye on a clear moonless night, resembling a hazy star of the sixth magnitude. It was discovered by Halley in 1716, who described it as "a little patch." It is easily discernible in an opera-glass, but it takes a 4-inch telescope to resolve its stars. In our largest telescopes it is an inexpressibly wonderful sight. Those who live in the neighborhood of a large telescope should ask for permission to view the wonders such telescopes reveal. Astronomers are busy people but are always willing to oblige those interested when it is possible to do so.

Herschel estimated that it contained 14,000 stars. On a plate taken with the 60-inch reflector at Mount Wilson, by Professor Ritchey, with an exposure of 11 hours, Professor Shapley counted over 30,000 stars brighter than the 21st magnitude. Now the cluster is thought to comprise not less than 100,000 stars. (See plate facing p. 22.)

Parallax determinations, by indirect methods, have resulted in giving us, as an approximate distance of this cluster from our system, 36,000 light years. Professor Shapley's estimate of the diameter of the cluster is 320 light years. It is said to be approaching us at a rate of not less than 200 miles a second.

A study of the spectra of the stars in the cluster shows that the brighter stars are of the solar type, and are probably giants. Professors Shapley and Pease find the cluster somewhat ellipsoidal in shape.

HERCULES


Head of Draco
Vega
Lyra
Solstitial Colure
The Key-stone
Great Cluster 13 M
Masym
Kornephoros
Marfik
Ras Algethi double (var.)
Cujam

For the Telescope

The possessor of a small telescope will find in the following list of double stars many objects of interest and beauty.

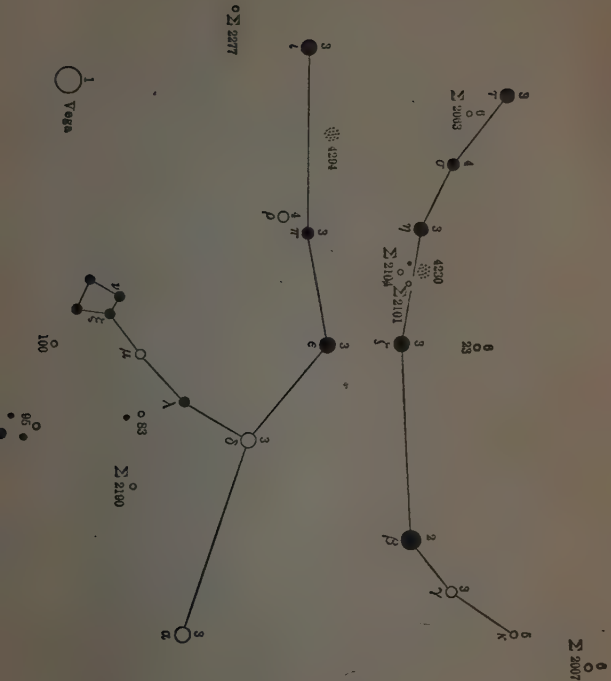
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	3.5–5.4	5	113	Yellow–Blue. Orange–Green also given.
δ	3–8	15	195	Green–Purple. Variable.
γ	3.8–8	40	240	White–Lilac.
ρ	4.5–5.5	4	312	Both green.
95	5–5.2	6	262	Apple green–Cherry red.
κ	5–6	31	10	Yellow–Red.
Σ 2101	6–9	4	60	
Σ 2104	6–8	6	19	Fine double.
μ	3.5–8	31	245	
500	6–6	14	182	A beauty.
Σ 2067	6.5–8	32	328	
Σ 2190	6–9.5	10	23	
23	6–9	34	18	
Σ 2063	5.7–8.2	16	194	
Σ 2277	6.3–8.2	28	117	

The companion to delta Herculis has no connection with it, for the two stars are moving in different directions, and in a few centuries will be widely separated.

The companion of mu Herculis is traveling with its primary at the rate of 80 seconds of arc per century. It is 31 light years distant. The faint companion is a close double whose components complete a revolution in their orbits in about 45 years.

One of the smallest stellar masses concerning which we have any reliable knowledge, belongs to the companion of the double star ζ Herculis. It is from one-third to one-fourth the sun's mass. Professor Russell informs us that this star is 23.2 light years distant, and moves across the sky at the rate of 12.5 miles a second. It is approaching us at the rate of 47 miles a second. It follows that this star is actually moving at the rate of 49 miles a second in a line which makes an angle of only fifteen degrees with the line joining it with the sun. Some 85,000 years hence it will appear as bright as Arcturus does now.

HERCULES



Σ 2277
Vega
4204
Σ 2003
4220
Σ 2104
Σ 2101
23
Σ 2190
100
95
83
Σ 2007

BOÖTES

BOÖTES (bō-ō′-tēz)—THE HERDSMAN, OR BEAR DRIVER (Face West)

LOCATION.—Boötes lies just west of the Crown, and east of the star Cor Caroli. It may be easily distinguished by the position and splendor of its principal star, Arcturus, which shines with a golden yellow light. Arcturus is about thirty-five degrees east of the star Denebola in Leo, and nearly as far north of Spica the brilliant first magnitude star in Virgo. It forms with these two stars a large equilateral triangle. A line drawn from ζ to η Ursæ Majoris and prolonged about thirty degrees locates Arcturus, as does one from δ Herculis to γ Coronæ prolonged its length.

Mythology

> Whose order'd beams
> Present a figure driving on his teams,
> Below his girdle, near the knees, he bears
> The bright Arcturus, fairest of the stars.
>
> MANILIUS.

There is considerable variance in the mythology relating to the constellation Boötes. According to some of the Greeks, Boötes represented Icarius, the father of Erigone. Others considered it to be Erichthonius, the inventor of the chariot.

According to another legend Boötes represented Arcas, the son of Zeus and the nymph Callisto, who having been robbed of his possessions by his brother, after many hardships and wanderings, invented a plough, which was drawn

by two oxen. With this he tilled the soil and made a living. His mother Callisto was so highly pleased with his invention and industry that she induced Zeus to place her son in the sky together with his plough.

There is a similarity in mythology between the constellations Boötes and Auriga. In both constellations we see figures representing famous inventors.

Boötes has been called "Atlas" from its nearness to the Pole, and because the figure appeared to hold up the heavens.

Plunket claims 6000 B.C., and latitude 45° North, for the time and place of the invention of this constellation, as at that time and latitude Boötes might be seen at midnight of the summer solstice, standing upright on the northern horizon, his head reaching nearly to the Pole. Never since that date has he held so commanding a position in the sky, nor at any other southern latitude could his whole figure have been represented as standing on the horizon.

The trapezium formed by the stars β, γ, δ, and μ Boötis was called "the Female Wolves" by the Arabs. They knew the stars θ, ι, κ, and λ Boötis as the "whelps of the Hyenas."

The Arab name for the constellation Boötes was "the Vociferator."

The ancient Greeks called the constellation "Lycaon," a name signifying a Wolf. The Hebrews knew it as "the Barking Dog."

Boötes is among the first constellations recorded. Homer referred to it in the Odyssey.

The word means a Ploughman, or according to some authorities an Ox-Driver. The Greeks called it the "Bear-Driver" because the figure appears to drive the Great Bear about the Pole.

The constellation is represented on the old atlases by the figure of a man in a running attitude. In one hand he holds a staff or spear, in the other he holds in leash the two hunting dogs, Asterion and Chara, that form the constellation of the Canes Venatici.

There is a wealth of interesting information regarding the star Arcturus, the feature of the constellation Boötes. It has been called "the Watcher" or "Guardian of the Bear." The Arabs knew the star as the "Keeper of Heaven," and twelve hundred years ago it was an important star in the eyes of the husbandmen. In Hesiod's "Work and Days" we read:

> When in the rosy morn Arcturus shines,
> Then pluck the clusters from the parent vines:
> And when Arcturus leaves the main to rise
> A bright star shining in the evening skies,
> Then prune the vine.

Arcturus is also called "Job's Star," because of the reference to it in the Book of Job, although this reference is now supposed to relate to Ursa Major.

For the Naked Eye and Field Glass

Boötes is a conspicuous constellation. Lines connecting its bright stars outline a kite-shaped figure. Three stars of the fourth magnitude are situated in the right hand of the Herdsman. They are about five degrees north of η Ursæ Majoris.

Contrast the colors of the stars Arcturus, Spica, Antares, and Vega.

Arcturus is the fourth brightest star in the northern hemisphere, and one of the most remarkable. Its magnitude is 0.2. Arcturus is 41 light years distant, and about 100 times as bright as our sun. The diameter of Arcturus measured by Professors Michelson and Pease is twenty million miles, roughly 25 times the sun's diameter and seven times its area.

The heat derived from Arcturus from measurements by Professor E. F. Nichols, indicates that it is equal to that received from a single candle at a distance of five miles away. According to Professor Adams the spectrum of Arcturus resembles that of a sun spot.

The most remarkable fact about Arcturus is its great proper motion, that is, its annual displacement on the celestial sphere in seconds of arc. Its motion was first detected by Halley in 1718. He announced that Arcturus, Sirius, and Procyon had changed their position since ancient times. These were the first stars discovered to be moving and not absolutely fixed. Now we know that all the stars in the universe are in motion.

The mean of three authoritative determinations of the proper motion of Arcturus is 84 miles a second in the direction of the constellation Virgo. Of all the bright stars in the heavens, Arcturus has the most rapid motion.

Arcturus is one of the so-called "Giant Stars," that is, a star of low temperature and low density which is at the beginning of its career as a star.

The brightness of Arcturus was most impressive on October 5th, 1858, when Donati's comet swept over it. On that night its golden light flashed through the comet

(Continued on next page.)

For the Naked Eye and Field Glass—*Continued*

very vividly when it was only twenty minutes of arc from the nucleus. It was remarked that the sight was rarely beautiful.

The light of Arcturus when analyzed shows that it is of spectrum type K.

Astrologically, Arcturus portended honor and riches, but near the equinoctial season its appearance signified inclement weather and poor harvests. The star rises at sunset on March 30th, and sets 14½ hours later. It culminates at 9 P.M. June 8th.

The third magnitude star Nekkar, or beta Boötis, marks the head of the Herdsman. It forms with delta and gamma Boötis nearly a right-angled triangle.

Seginus, or gamma Boötis, a third magnitude star, is in the left shoulder of the figure, nearly twenty degrees from the star Cor Caroli in Canes Venatici.

The little triangle of fourth magnitude stars near the end of the handle of "the Dipper" marks the uplifted hand of the Bear-Driver, in which he holds in leash the Hunting Dogs.

The tip of the staff or spear which the Herdsman holds in his right hand is marked by the fourth magnitude star Alkalurops, or μ Boötis. It has two companion stars.

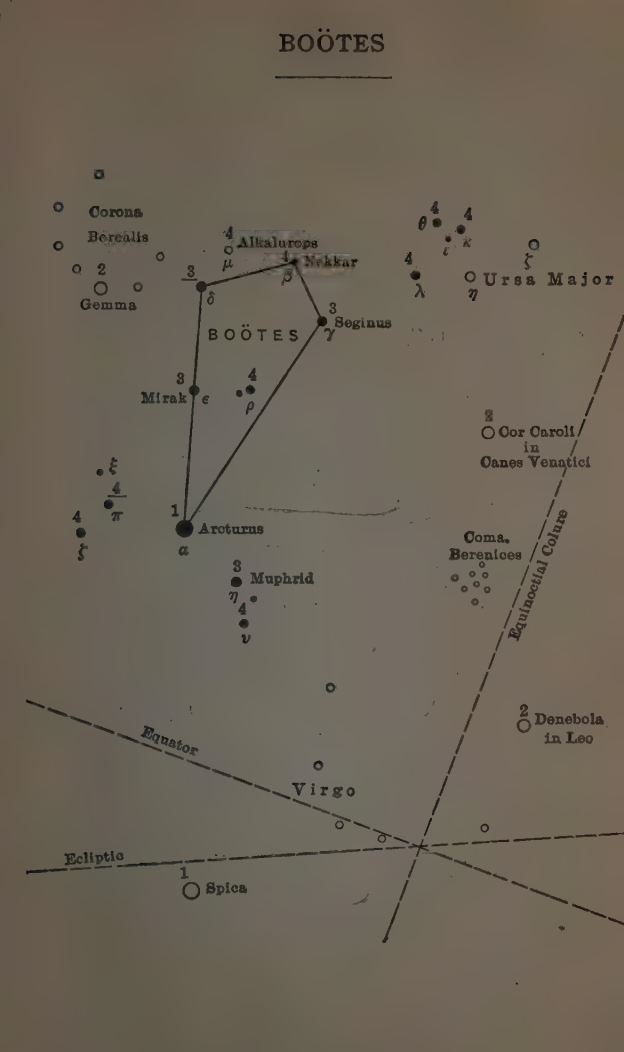
Nearly five degrees south of μ Boötis is δ Boötis, a third magnitude star. A field glass reveals that it has an eighth magnitude companion at a distance of less than two minutes of arc.

The right ankle of the Herdsman is marked by the 3.8 magnitude star ζ.

Eta is a third magnitude star situated in the left knee of the Bear-Driver. It has a distant companion of lilac hue of about the tenth magnitude.

There is an attractive group of stars to be viewed with a field or opera glass near the star θ.

BOÖTES


Corona
Borealis
2
Gemma
4
Alkalurops
μ
3
δ
4
Nekkar
β
3
Seginus
γ
BOÖTES
3
Mirak
ε
4
ρ
ξ
4
π
4
ζ
1
Arcturus
α
3
Muphrid
η
4
ν
4
θ
4
ι
κ
4
λ
ζ
η
Ursa Major
2
Cor Caroli
in
Canes Venatici
Coma
Berenices
Equinoctial Colure
2
Denebola
in Leo
Equator
Virgo
Ecliptic
1
Spica

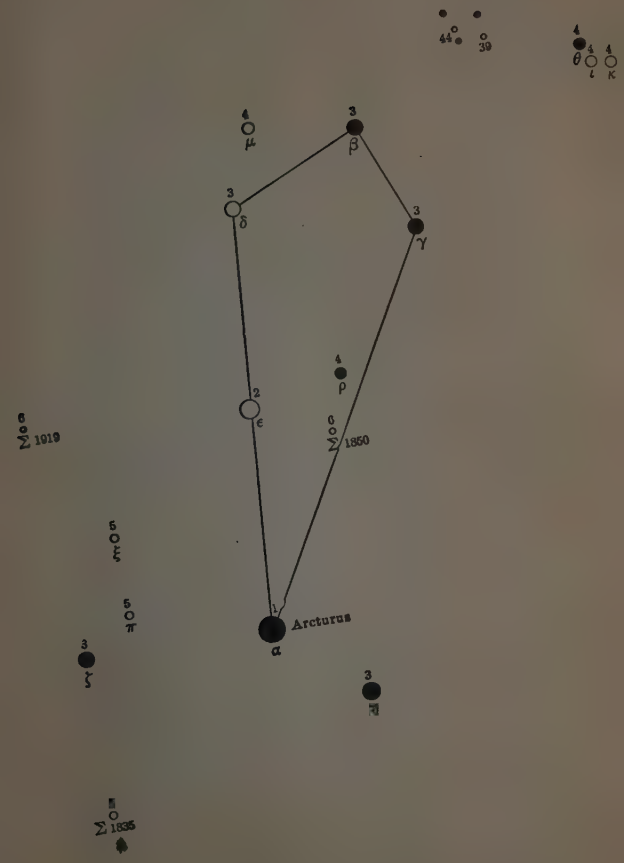
For the Telescope

The constellation Boötes offers many interesting double stars for the possessors of small telescopes. A partial list is given below, and their location is designated on the Chart.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
π	4.9–6.0	6	104.5	Both white.
δ	3.6–8.0	105	79	Yellow–Blue.
μ	4.5–6.7	108	171	
44	5.2–6.1	3	234	A binary. Period 261 years.
39	6–6	3	45	Fine contrast of colors.
ι	5.0–7.5	38	33	Yellow–White.
κ	4.6–6.6	13	238	White–Blue. A beautiful object.
Σ 1919	6–7	25	10	Yellow–White.
Σ 1850	6.0–6.7	26	262	Yellow–Blue.
Σ 1835	5.5–6.8	6	190	
ξ	4.7–6.6	3	200	Yellow–Purple. Fine contrast.
ε	3.0–6.3	2.7	331	Orange–Green. A superb object. Test for 2 inch glass.

ε was called "pulcherrima" by the elder Struve on account of its extreme beauty. Yellow and bluish are colors attributed to its components. It is the περιζώμα of Ptolemy, but appears as Izar in various catalogues, from the Arabian word signifying "a zone or girdle." It is also designated "Mirak," meaning a girdle or loins.

BOÖTES


44
39
4
θ
4
ι
4
κ
4
μ
3
β
3
δ
3
γ
4
ρ
2
ε
6
Σ 1919
6
Σ 1850
5
ξ
5
π
1
Arcturus
α
3
ζ
3
η
5
Σ 1835

VIRGO

VIRGO (ver′-gō)—THE VIRGIN (Face West)

LOCATION.—A line drawn from Antares in the Scorpion, through alpha Libræ, prolonged a little over twenty degrees, strikes the first magnitude star Spica (alpha Virginis), the brightest star in the constellation Virgo.

Spica is about thirty degrees southwest of Arcturus in Boötes. The stars Arcturus, Cor Caroli, Denebola, and Spica form a figure about fifty degrees in length, called "the Diamond of Virgo."

VIRGO

Mythology

Below Boötes thou seest the Virgin
An ear of corn held sparkling in her hand.

ARATOS.

The constellation Virgo is one of the most ancient of the stellar groups.

According to an old myth, Virgo represents Astræa, the daughter of Jupiter and Themis, the goddess of Justice. During the Golden Age, when, it is said, the gods lived upon the earth, Astræa ruled the world, and was held in high respect by all mankind.

Times changed, and in the succeeding Brazen and Iron Ages, the wickedness of mankind offended the goddess, and she left the world to its fate. She took her place in the golden girdle of the Zodiac, with the Scales of Justice, represented by the constellation Libra, beside her.

In Egyptian mythology, Virgo was associated with the goddess Isis. It is related that, when pursued by the monster Typhon, she dropped the sheaf of corn which she held in her hand, and the scattered corn became the faint glistening stars that form the Milky Way.

The star Spica was known in ancient times as "the Star of Prosperity." The Egyptians worshipped this star, and built temples in its honor. The name Spica means an "ear of wheat." In the old atlases the Virgin is always depicted as holding a sheaf of wheat in her left hand, marked by the star Spica.

For the Naked Eye and Field Glass

The Equator, Ecliptic, and Equinoctial Colure, great circles on the celestial sphere, intersect at a point close to the star η Virginis. This point is called the "Autumnal Equinox."

The star ε Virginis bears the name "Vindemiatrix," which means "the Grape Gatherer." It rises just before the sun at vintage time.

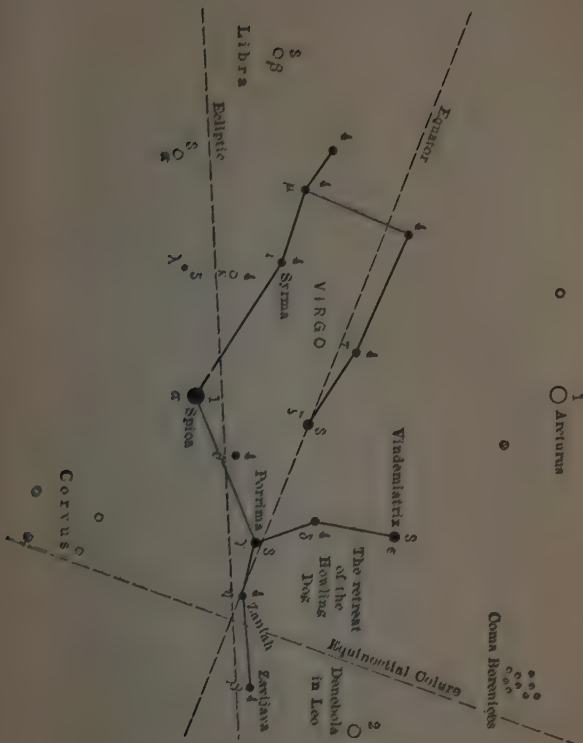
Within the rude square formed by the stars Denebola, in Leo, and ε, γ, and β Virginis, the telescope reveals many wonderful nebulæ. This region of the sky has been called "the Field of the Nebulæ." Herschel discovered 323 nebulæ in the constellation.

Spica is an extremely beautiful pure white star of the Orion type. It rises a little south of the exact eastern point on the horizon at 9 P.M., March 9th, culminates March 26th, and sets August 12th, at 9 P.M.

Hipparchus, while plotting the position of the stars, noted a discrepancy in the place assigned Spica by an earlier Greek astronomer. Investigation of this matter led him to his famous discovery of the Precession of the Equinoxes.

Spica is 235 light years distant, with a proper motion of 11 miles a second. It is estimated to be 1500 times brighter than the sun, and at a surface temperature of 19,000 degrees centigrade.

VIRGO



Libra
Ecliptic
Equator
VIRGO
Syrma
Spica
Porrima
Vindemiatrix
Arcturus
Corvus
The retreat of the Howling Dog
Zanjah
Zavijava
Equinoctial Colure
Denebola in Leo
Coma Berenices

For the Telescope

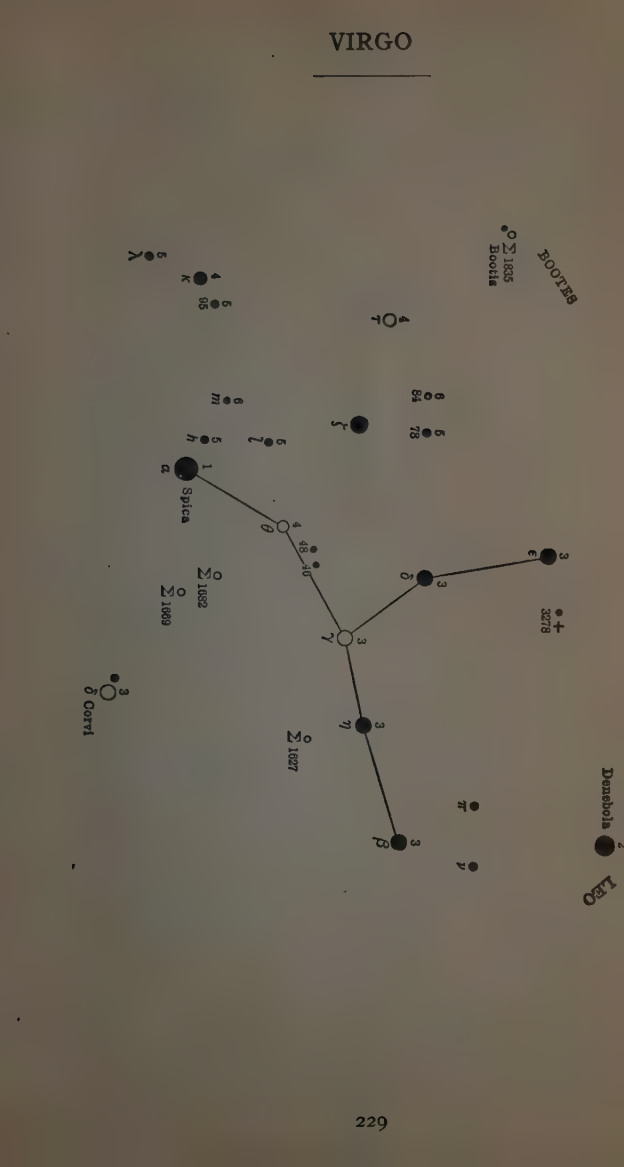
It is not possible to do more than glimpse the nebulæ that feature this constellation, but the telescopist will find the following double stars interesting objects to observe.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
γ	3.7–3.7	6	326	Both yellow. A beautiful object.
Σ 1669	6–6	5	124	A fine pair.
τ	4–8.5	79	290	
Σ 1627	6–6.4	20	196	
Σ 1682	6.7–9	34	309	Yellow–Red.
θ	4.5–9–10	7	344	A triple star.
		71	297	

γ Virginis is a famous double star, resembling Castor, in Gemini. In 1756 the distance between the components was six seconds. In 1836 the two stars were so close together that they could not be separated with the largest telescopes. Now the stars are again six seconds apart and the distance between them is widening. This star is best observed in the twilight or moonlight. Its period of revolution is 180 years, and almost a complete revolution has been observed.

The "+" locates the nebula 3278. Webb says it resembles a paper kite, and that it is beautifully grouped with three stars. There are two nebulæ in the field.

VIRGO



BOOTES
Σ 1835
Bootis
Spica
Σ 1682
Σ 1669
Σ 1627
δ Corvi
Denebola
LEO

N
S.
E.
W.
Cor Caroli
Arcturus
Solstitial Colure
The Pointers
North Pole
Polaris
Capella
The Kids
Nath
Aldebaran
Hyades
Pleiades
Algol
Hamal
Mira
Al Rischa
Great Neb.
The Great Square of Pegasus
The Circlet
Equinoctial Colure
Over Head
Deneb
Vega
Ras Alhague
Sobieski's Shield
The Milk Dipper
The Bow
Altair
The Water Jar
Equator
ECLIPTIC
Fomalhaut
PISCIS AUSTRALIS
GRUS
CAPRICORNUS
SAGITTARIUS
CORONA AUSTRALIS
AQUILA
SAGITTA
DELPHINUS
CYGNUS
LYRA
CERBERUS
HERCULES
OPHIUCHUS
SERPENS
CORONA BOREALIS
BOÖTES
DRACO
URSA MINOR
URSA MAJOR
CANES VENATICI
LYNX
AURIGA
PERSEUS
CASSIOPEIA
CEPHEUS
ANDROMEDA
TRIANGULUM
ARIES
PISCES
CETUS
PEGASUS
AQUARIUS

THE CONSTELLATIONS OF AUTUMN

The folding map opposite shows the principle stars visible from Latitude 40° N. at:

9:00 P.M. October 1st

9:30 Sept. 22	8:30 Oct. 8
10:00 Sept. 14	8:00 Oct. 14
10:30 Sept. 7	7:30 Oct. 22

The Times are Eastern Standard.

Chart held in this position depicts Southern sky. Quarter turns of the book from left to right give correct views successively of Eastern, Northern and Western sky.

CASSIOPEIA

CASSIOPEIA (kas-i-ō-pē′-ya)—THE LADY IN THE CHAIR (Face North)

LOCATION.—A line drawn from δ Ursæ Majoris, through Polaris, locates alpha Cassiopeiæ. The constellation is situated the same distance from the Pole as Ursa Major, and lies about midway between Polaris and the zenith in the Milky Way. It is a rich and interesting constellation, and contains no less than one hundred bright stars.

The constellation is characterized by a zigzag row of five second and third magnitude stars which form a rude and widespread figure resembling the letter "W," but, in mid-Autumn, to an observer facing North, the "W" appears inverted and resembles the letter "M," which is almost overhead.

The star β Cassiopeiæ is equidistant from the Pole and exactly opposite the star Megres, δ Ursæ Majoris. With alpha Andromedæ, and γ Pegasi, it marks the great celestial circle known as the equinoctial colure. These stars are known as "the Three Guides."

Mythology

> . . . that starred Ethiop's Queen that strove
> To set her beauty's praise above
> The sea nymphs, and their power offended.
>
> MILTON.

The constellation Cassiopeia dates as far back as 3500 B.C. The most famous of the legends concerning it is from the Greeks and relates that Cassiopeia was the beautiful wife of Cepheus, King of Ethiopia, and the mother of Andromeda.

Cassiopeia appears to have been a vain and conceited personage, and lacking in tact, for she is said to have openly boasted that she was more beautiful than the sea nymphs.

The sea nymphs were naturally incensed at her attitude and informed the god Neptune, who ruled the sea, of what they regarded as an insult to them. Neptune approved of their case, and sent a sea monster to ravage the coast of Ethiopia, and to punish Cassiopeia for her temerity decreed that Andromeda, Cassiopeia's beautiful daughter, should be chained to a rock by the seashore as a prey and tribute to the monster. The sequel of the story relating to Andromeda's escape from her cruel fate is told in the legend concerning the constellation Andromeda.

Cassiopeia was later transported to the sky, and placed in a starry chair which circles the Pole, and subjects the Queen to the torment of standing on her head at times. As the poet Aratos puts it:

She headforemost like a tumbler sits.

Cassiopeia is sometimes called "Heaven troubled Queen" and "Unhappy Cassiopeia."

The Arabs fancied that they saw a Hand in the stars of the constellation, and also called the constellation "the Kneeling Camel."

The Egyptians called it "the Leg," the Eskimos a "Stone Lamp," and the Greeks a "Key."

For the Naked Eye and Field Glass

Observe with an opera or field glass the region around the star γ, also the beautiful double cluster of stars between Cassiopeia and Perseus.

The stars β, α and γ Cassiopeiæ outline three of the four corners of the back of the famous Chair, in which Cassiopeia is supposed to be seated. The stars δ and ϵ mark one of the front legs of the chair.

The word "bagdei," made up of the Greek letter names of the principal stars in the constellation, is of assistance in memorizing them.

The stars γ and β are pointer stars to a fifth magnitude star, the lucida or brightest star in the inconspicuous asterism of Lacerta, the Lizard, which lies about fifteen degrees from β.

The constellation Cassiopeia has a utilitarian feature of interest. It makes an excellent timepiece, and can be regarded as an illuminated clock. With a little practice it is possible to determine the time of night with approximate exactness by observing the changes in the position of its stars with reference to the Pole. This information should be of interest and service to Boy Scouts.

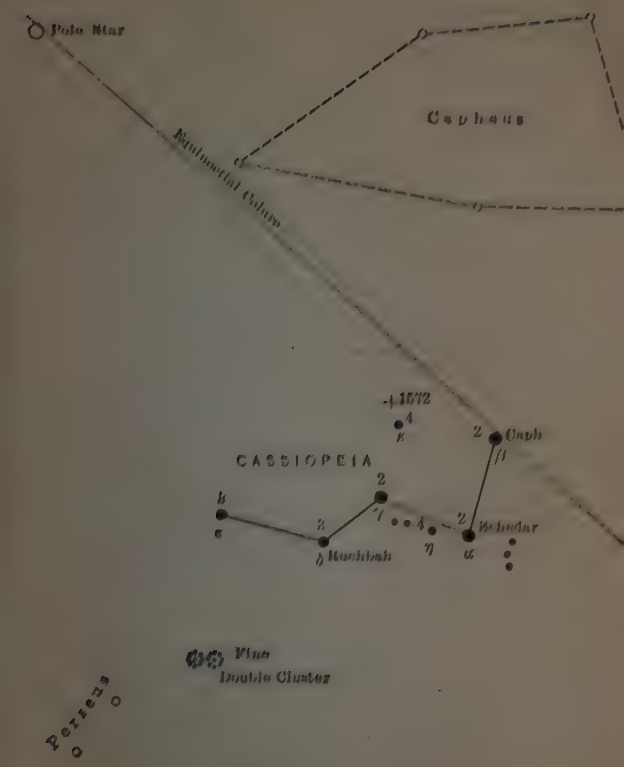
Professor Russell gives the following directions for deriving time from the observation of these stars:

"The line through Polaris and β Cassiopeiæ points about exactly to the vernal equinox. It may, therefore, be used as an indicator to estimate the Sidereal Time, remembering that it is above the Pole at sidereal noon, to the left at 6h., below at 12h., and to the right at 18h. With a little practice it is possible to read sidereal time from this celestial hour hand within about fifteen minutes. Then by recalling that the sidereal clock agrees with the mean solar clock on March 22nd (or thereabout) and gains at the rate of two hours a month, one can pass to ordinary solar time."

According to a recent parallax derived by Professor Mitchell, the star alpha Cassiopeiæ is 130 light years distant from us. It is a star of the solar type.

(Continued on page 236.)

CASSIOPEIA


Pole Star
Cepheus
Equinoctial Colure
+1572
4
2
Caph
CASSIOPEIA
2
2
2
Schedar
Ruchbah
Fine
Double Cluster
Perseus

For the Naked Eye and Field Glass—*Continued*

β Cassiopeiæ is a comparatively near neighbor of ours at a distance of 32 light years. It has a proper motion of ten miles a second.

The star γ has a ninth magnitude companion at a distance of 432″.

η was discovered by Herschel in 1779. It is a binary with a period, according to Doberck, of 222.5 years. Duner gives 176 years. It is 17 light years distant. η and the star 70 Ophiuchi are similar systems, both have about the same proper motions and parallax, and identical spectra of the solar type.

The star μ is 30 light years distant, and is notable for its large proper motion of 100 miles per second.

Sweep with a field or opera glass about γ.

Note the "+" marked 1572 on the Chart. This marks the place where a famous new star appeared. It was first seen November 11th, 1572, and is always associated with the name of the famous astronomer Tycho Brahe, who made a special study of it, and wrote a detailed description, which has come down to us. Two faint telescopic stars still exist near the place he deduced for the Nova, but it is not certain that either is identical with it. The star was bright enough at maximum to be seen in full sunshine, and rivaled Venus in brilliance. It is known as "Tycho's Star."

For the Telescope

Referring to the telescopic objects in the constellation Cassiopeia, Webb says: "Here lies a multitude of superb Galaxy fields." A mine of interest is here revealed for the happy possessor of a telescope. A partial list of the double stars is given below. There are many beautiful star clusters in the constellation, and to sweep over the region with a telescope or even a good field glass is to sense rare beauty.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	2–9	62	280	Reddish–Blue.
η	3.7–7.6	6	223	Yellow–Purple.
σ	5.5–7.5	3	324	Green–Blue. Color intense, grand field with low power.
ψ	4.5–8.5	30	101	
ι	4.8–7.1–8.1	7	112	Yellow–Blue–Blue. 3″ glass shows only two.
Σ 163	6.2–8.2	35	34	Gold–Blue. Remarkable colors.
Σ 3053	6–7.3	15	70	Yellow–Blue.
Σ 191	6–8.5	5	190	
OΣΣ 26	6–6.6	63	199	Orange–Green.

γ and κ lie in very rich fields. Half way between them note a fine cluster somewhat in the shape of a letter "W." Between π and ο is a glorious field.

The cluster 392 is a beautiful object, 15 minutes in diameter, and rich in stars. The cluster 5031 was discovered by Caroline Herschel in 1783.

The cluster 256 contains a double star, magnitudes 8.0 and 9.0.

Note 4957, a fine cluster, discovered by Herschel in 1788.

CEPHEUS

CEPHEUS (sē′-fūs)—THE KING (Face North)

LOCATION.—A line drawn from α to β Cassiopeiæ, and prolonged eighteen degrees, strikes α Cephei. The nearest bright star west of Polaris is γ Cephei.

Cepheus is an inconspicuous constellation lying partly in the Milky Way. The constellation is characterized by a rude square, one side of which is the base of an isosceles triangle.

α Cephei forms an equilateral triangle with Polaris and ε Cassiopeiæ. Owing to the Precession of the Equinoxes, γ, β and α Cephei will be successively the Pole Star in the years 4500, 6000, and 7500 A.D., respectively.

CEPHEUS

Mythology

Cepheus illumes
The neighboring heavens; still faithful to his queen.

It is claimed that this constellation was known to the Chaldeans twenty-three centuries before our era.

The constellation was held in high esteem by the ancients, and we find the King's story in the literature of Greece as far back as the fifth century B.C.

Cepheus was the King of Ethiopia. He was the husband of the beautiful and unfortunate Cassiopeia, who is placed near him in the sky with her daughter Andromeda.

The King is depicted in the old atlases of the heavens as seated on his throne in regal state, holding his scepter upraised in his left hand, and holding his robes with his right.

It is said that Cepheus was one of the famous band known as "the Argonauts," who accompanied Jason on his dangerous expedition in quest of the Golden Fleece. Because of the part he played in this famous expedition he was honored by a place high among the stars.

The Chinese, whose study of the stars goes back to very ancient times, also regarded this star group as representing royalty. Here it was that they placed the "Inner Throne of the Five Emperors."

The Arabs, however, pictured in this region of the sky a pastoral scene, including a shepherd and his dog guarding a flock of sheep.

For the Naked Eye and Field Glass

Observe with the naked eye the so-called "Garnet Star," μ Cephei, and compare its unusual light with the white star α Cephei.

Professor Russell tells us that spectroscopic observations of β Cephei, a double star, show that the principal star in the pair is a very close binary in exceedingly rapid revolution, completing its orbit in less than five hours, the most rapid orbital revolution so far known.

Many small meteor showers radiate from this constellation during the middle and latter part of June.

δ Cephei is a beautiful double star (use a field glass) and has been likened to the famous double, β Cygni. It is a noted Variable Star. At maximum of 3.7 magnitude, at minimum 4.6 magnitude. Period 5 days, 8 hours, 47 minutes, and 39 seconds. As it is about 2½ times as bright at maximum as at minimum, the star can be observed with the naked eye, and is an interesting observation. The best explanation of the light changes of this star is Eddington's: it pulsates. (See p. 29.)

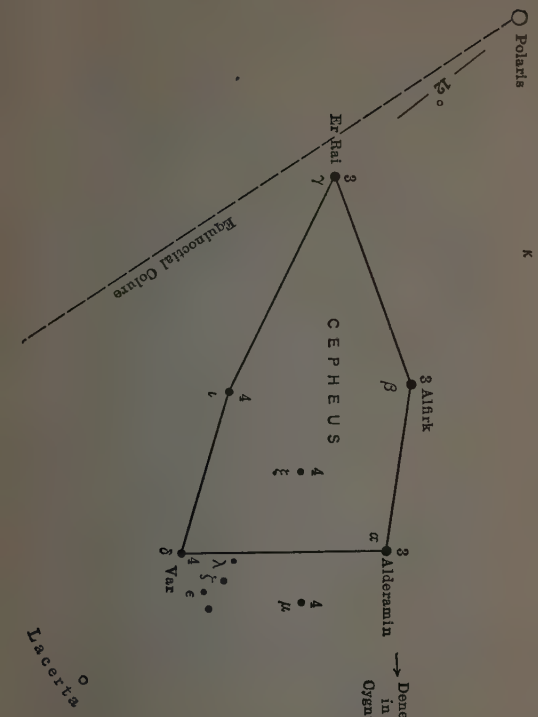
It is this star which gives the name to the class of variable stars known as Cepheids, by whose special characteristics we are able to measure the distances of the far-lying spiral nebulæ and star clusters.

The star was discovered by Goodricke in 1784.

Surrounding the stars δ, ϵ, ζ and λ, which stars mark the head of the King, is a dark area in the Milky Way, one of the so-called "Coal Sacks" in the sky.

About four degrees from γ, in the direction of κ, is a pretty pair of sixth magnitude stars.

CEPHEUS


Polaris
4
κ
12°
Equinoctial Colure
Er Rai
3
γ
3 Alfirk
β
CEPHEUS
4
ι
4
ξ
3
α
3 Alderamin
→ Deneb in Cygnus
4
μ
δ Var
λ
ζ
4
ε
Lacerta

For the Telescope

Webb says of this constellation: "Much more barren to the naked eye than to the telescope. Splendid sweeps and curious groups between alpha Cephei and Galaxy."

The constellation contains a great number of double stars: a partial list is given below. For a more complete list see Webb's "Celestial Objects for Common Telescopes," a classic.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
β	3.3–8	13	250	White–Blue.
δ	var. 3.6 to 4.5–7.5	41	192	Yellow–Blue. Field glass double.
ξ	4.4–6.5	6	285	Both bluish.
κ	4–8	7	124	White–Blue.
Σ 2816	6–8–8	12	120	Triple
		20	340	
Σ 2893	5.5–7.5	28	348	Yellow–White.
Σ 2840	6–7	20	194	Greenish white–Bluish white. A splendid pair.
Σ 2873	6.2–7	13	77	
Σ 2883	6.2–8.2	15	254.7	White–Blue.

The double star Σ 3053, in Cassiopeia, is located on the Chart, as it is conveniently located for observation while this region is being explored. Magnitude 6–7; Distance 15″; Angle 70°. Yellow and blue.

CEPHEUS

4 θ
4 η
6 Σ 2840
6 Σ 2816
3 α
μ
3 ζ
5 ε
4 δ
5 ξ
3 β
6 Σ 2883
6 Σ 2893
3 ε
5
5
4 κ
6 Σ 2873
3 γ
6 Σ 3053
Cassiopeiae
Polaris

PEGASUS

PEGASUS (peg′-a-sus)—THE WINGED HORSE, AND EQUULEUS (Face South)

LOCATION.—One corner of the Great Square of Pegasus, a stellar landmark in this constellation, is located by drawing an imaginary line from Polaris to the constellation Cassiopeia, and extending it an equal distance.

Three of the four corners of the "Great Square" are marked by stars in Pegasus, the fourth, the northeastern corner, is marked by the star alpha Andromedæ which bears the Arab name "Alpheratz."

The horse is generally seen upside down in the sky, with his forefeet projected up into the heavens. Only the head, neck and forefeet of the animal are represented by stars. The star ε Pegasi marks the nose of the animal.

PEGASUS

Mythology

That poetic steed
With beamy mane, whose hoof struck out from earth
The fount of Hippocrene.

BRYANT.

In the old legends, Pegasus figured as the famous steed which sprang from the blood of the Medusa, after Perseus had decapitated her.

According to Ovid, his abode was on Mt. Helicon. It is said that there, by striking his hoof sharply on the ground, he caused water to gush forth, which was ever after known as the "Fount of Hippocrene."

PEGASUS

The horse Pegasus was tamed by either Neptune or Minerva, and seems to have been employed by Jupiter to carry the thunder and lightning. He became the property of Bellerophon, and Pegasus is said to have borne him through the air to Lycia, the abode of the terrifying Chimera. Bellerophon succeeded in destroying the creature, but the act did not please Jupiter, who sent a gad fly which stung Pegasus and he hurled his rider Bellerophon to the ground. Pegasus continued his flight to the heavens where he is to be seen even to this day.

Pegasus was regarded in Phœnicia and Egypt, in ancient times, as the sky emblem of a ship. The Greeks knew the constellation as "ἵππος."

The winged horse is found on coins of Corinth 500 to 430 B.C.

The Great Square of Pegasus is a stellar landmark easily defined with the naked eye, and important for everyone to know. It may be that the northern sky is obscured by clouds and other regions clear. A knowledge of even a few constellations will fix the points of the compass, often an important matter to determine. A knowledge of the Great Square of Pegasus once saved the lives of Donald MacMillan, the arctic explorer, and his companions when they were lost on the polar ice

For the Naked Eye and Field Glass

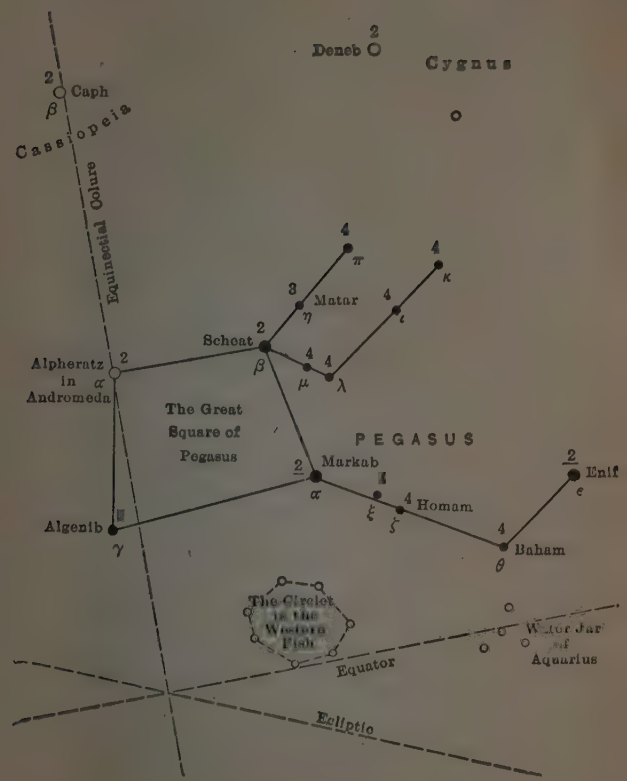
The position of the small asterism Equus, or Equuleus, the Little Horse, is shown in the telescopic diagram.

The location of the equinoctial colure, one of the great circles on the celestial, is defined by a line connecting the stars Polaris, alpha Andromedæ, and γ Pegasi.

β Pegasi is a giant star, 75 millions of miles in diameter. It is receding from us at a speed of five miles a second. It is also a Variable star.

The stars alpha, beta and epsilon Pegasi are 191, 325 and 145 light years distant, respectively.

The fourth magnitude star π has close to it another which some atlases mark π^2. They are a pretty pair in a field glass.


Deneb
Cygnus
Caph
β
Cassiopeia
Equinoctial Colure
π
κ
Matar
η
ι
Scheat
β
Alpheratz
in
Andromeda
α
μ
λ
The Great
Square of
Pegasus
PEGASUS
Markab
α
Enif
e
ξ
ζ
Homam
Algenib
γ
Baham
θ
The Circlet
is the
Western
Fish
Water Jar
of
Aquarius
Equator
Ecliptic

For the Telescope

The cluster 15 M was discovered by Maraldi in 1745.

β Pegasi is a Variable Star, and a giant star, 75 million miles in diameter. Within the "Great Square," Argelander counted 30 naked-eye stars. Note Σ 2894 Lacertæ, M. 6–8, D. 15″, A. 193°. Also 8 Lacertæ, a fine quadruple star, M 6–6.5–10.2–8.5.

π^1 and π^2 form a beautiful pair. North of them, two degrees, is the attractive double star Σ 2905, M. 8.5–8.5, D. 3″, A. 283°.

ϵ Pegasi exhibits a phenomenon noted by Herschel, viz.: the pendulum-like oscillation of a small star in the same vertical with a large one, when the telescope is swung from side to side; merely an optical illusion of course.

κ and η Pegasi have eleventh magnitude companions, at a distance of 162 degrees and 90 degrees respectively.

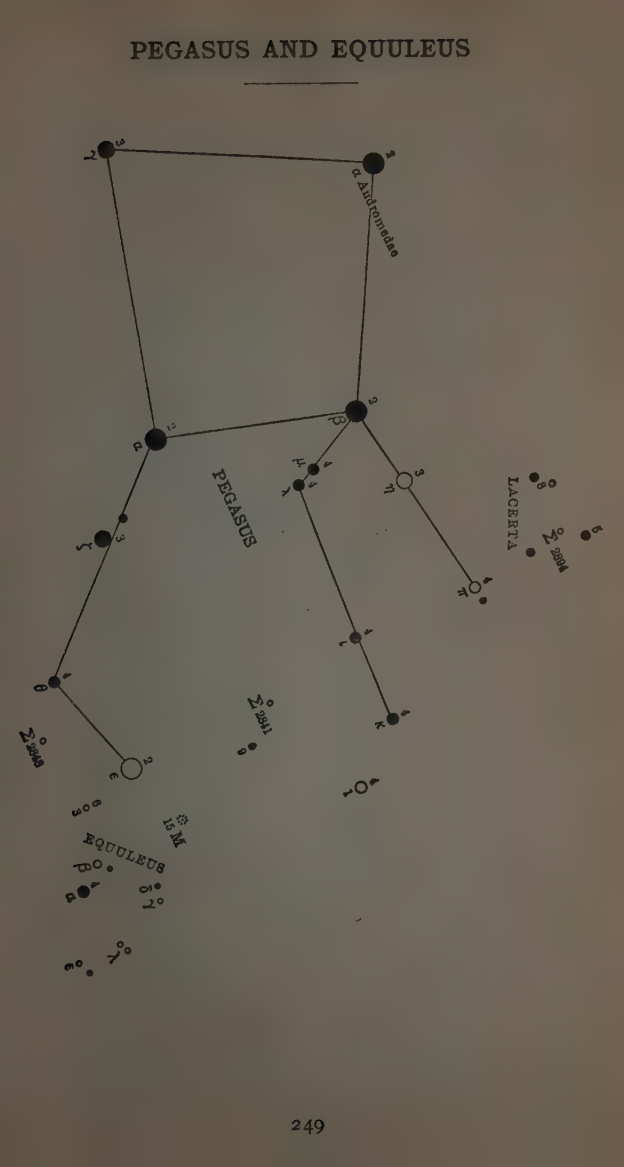
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ϵ	2.5–8.5	138	323	Yellow–Violet. Fine contrast.
I	4.5–8.5	36	311	
3	6–7.5	39	349	Another fine pair on this field.
Σ 2841	6.5–8	22	111	
Σ 2848	7–7.5	10	54	

The following double stars in Equuleus will be found in this region:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ϵ	6–7	11	77	White–Blue.
λ	7–7	2.6	224	A fine pair.
γ	4.2–11.0	2	274	
β	5–10.5	67	309	

δ has a very close fifth magnitude companion. It is supposed to have a period of only 5.7 years, the shortest, excepting two, yet discovered for a visual binary.

PEGASUS AND EQUULEUS



ANDROMEDA

ANDROMEDA (an-drom′-e-da)—THE CHAINED LADY (Face Southeast)

LOCATION.—The star alpha Andromedæ is situated at the northeastern corner of the Great Square of Pegasus, one of the stellar landmarks. The constellation is especially favorable for observation during the early evening hours of September, rising in the eastern sky.

Running east from alpha Andromedæ, at almost equal distances, are four other stars, three of which are of the second magnitude. The star farthest east is alpha Persei. These five stars strung out along the eastern sky, like pendant lamps, present a charming appearance.

Mythology

> And there revolves herself, image of woe,
> Andromeda beneath her mother shining.
>
> ARATOS.

The most famous legend relating to the constellation Andromeda is of Grecian origin. According to the story, Andromeda was the beautiful daughter of Cepheus, King of Ethopia. Her mother, Queen Cassiopeia, enraged the sea nymphs by boasting of her beauty. Neptune, in order to punish her for her vanity and conceit, decreed that her cherished daughter Andromeda should be chained to a rock by the seashore, where she would become the prey of a terrible sea monster that was ravaging the coast.

The unfortunate maiden was forced to submit to this barbarous treatment, and in chains awaited her sad fate as the monster drew nigh. Luckily, just as the monster was about to seize her, Perseus the Champion flew down to her

rescue bearing with him the hideous head of the Medusa. He held this up before the monster's eyes and straightway the creature was turned into stone, and Perseus gallantly released Andromeda. The story is delightfully told by Charles Kingsley in his "Greek Heroes."

For the Naked Eye and Field Glass

The chief object of interest in the constellation Andromeda is the great nebula, the first to be discovered. It can be seen by the naked eye, and it is a fine sight even in an opera glass. In a large telescope it is a glorious object.

The nebula has been called the "Queen of the Nebulæ," and is said to have been known as far back as A.D. 905. It was described in A.D. 986 as the "Little Cloud," and was one of the first conquests of Galileo.

Toward the close of 1913 Dr. Slipher, of the Lowell Observatory, announced that he had secured a spectrogram of the Andromeda Nebula which showed that it was approaching us at the rate of 187 miles a second.

In 1885, a new star appeared close to the center of the nebula that was almost bright enough to be visible to the naked eye. Its calculated brightness at maximum was 400 million times that of the sun. Recent investigations have shown that as many as 44 new stars have appeared within the nebula. Professor E. H. Hubble discovered some Cepheid Variable stars in the Nebula, and was enabled to calculate that their distance from us was approximately one million light years. When we realize that one light year is the distance travelled by light in one year at the rate of 186,000 miles a second, we grasp in some measure the vastness of space.

There is every reason to suppose that these stars discovered within the nebula are associated with it, and that the nebula itself is at the distance from us stated above.

Authorities state that the diameter of this nebula is more than 3 thousand, million times the distance from the

(Continued on next page.)

For the Naked Eye and Field Glass—*Continued*

earth to the sun. It would take light 50,000 years to traverse this nebula.

The outer part of the nebula, usually photographed as nebulosity, has been resolved into myriads of stars on photographs taken with the 100-inch reflector at Mount Wilson.

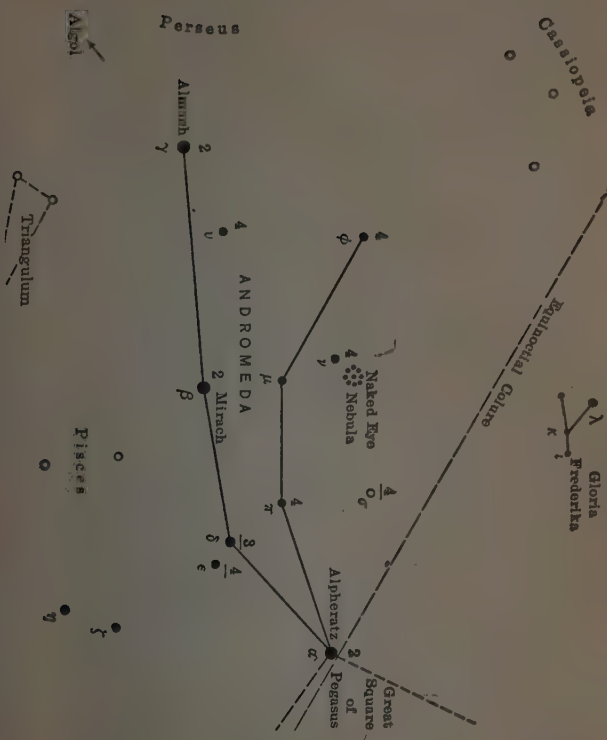
Professor H. N. Russell considers it to be by far the brightest object that has been measured, and that it must be a billion times as bright as the sun. All the stars visible to the naked eye, if taken together, would not equal this great nebula in brightness.

Observe the Nebula with naked eye, opera or field glass. It is one of the marvels of the heavens, and the only spiral nebula visible to the naked eye.

The double star 56 can be separated with a field glass if it is held steadily. Some observers mount their binoculars on a tripod which enables them to view objects undiscernible when the glass is held in the unsteady hand.

Alpha Andromedæ, known to the Arabs as "Alpheratz," meaning "The head of the woman in chains," is shown by the spectroscope to have a dark companion star revolving about it in a highly eccentric orbit, in a period of about 100 days. The system, as a whole, is approaching at the rate of eight miles a second.

The star γ Andromedæ marks the radiant point of the Bielid meteors associated with Biela's comet, which disappeared in the first half of the 19th Century. These meteors should be looked for on November nights between the 17th and 27th of the month. The stream travels very slowly, and the meteors are characterized by their yellowish color and their short trains.



(For Triangulum see Telescope Chart)

For the Telescope

The following stars are of telescopic interest. Their location is indicated on the Chart.

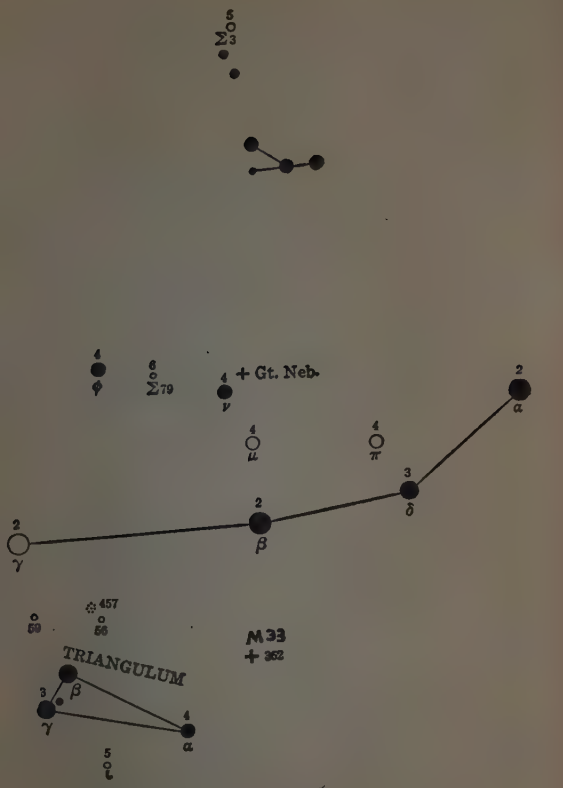
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
γ	2.3–5	10	63	Yellow or orange-Greenish blue. Beautiful contrast.
Σ 79	6–7	7	192	A fine pair.
π	4.5–9	36	174	White-Blue.
56	6–5.8	181	301	Field glass double.
59	6–7	16	34	Yellow-Blue.
Σ 3	7.5–8.5	5	84	
μ	4–11	36	122	A difficult test for a 3″ glass.

The + indicates the location of the great nebula. Use a field or opera glass to locate it.

Gamma Andromedæ is one of the most beautiful double stars in the heavens; the contrasting colors of the two stars is very fine. It was discovered by Mayer in 1788.

Note the "Y" shaped asterism known as "Gloria Frederika," or "Frederik's Glory," northeast of alpha Andromedæ and above the nebula.

(*For text on Triangulum see second page following*)


5
Σ3
4
φ
6
Σ79
4
ν
+ Gt. Neb.
2
α
4
μ
4
π
3
δ
2
β
2
γ
457
59
56
M 33
+ 352
TRIANGULUM
3
β
γ
4
α
5
ι

TRIANGULUM

TRIANGULUM (tri-an′-gū-lum)—THE TRIANGLE
(Face East)

LOCATION.—A line drawn from the star γ Pegasi to Algol in Perseus passes through β Trianguli.

The Triangle, isosceles in form, lies on its side, a clearly defined and beautiful figure just below Andromeda, and above Aries. It was in this locality that Piazzi discovered the asteroid Ceres, January 1, 1800, the first asteroid to be discovered.

Alpha Trianguli is sometimes called "Caput Trianguli." It culminates at 9 P.M. December 6th.

α and β Trianguli were in ancient times known as the "Scale Beam." According to Argelander the constellation contains fifteen stars. The Triangle is a very ancient constellation and was formerly named "Deltolton" from its likeness to the Greek letter Delta. It has been likened to the Trinity, and the Mitre of St. Peter.

Aratos thus refers to the constellation:

> Beneath Andromeda, three lines compose
> The Triangle. On two sides measured equal,
> The third side less.

For the small telescope Triangulum offers a fine double star.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ι	5–6.4	3	78	Yellow–Blue. An exquisite pair.

Both components of this double are spectroscopic binaries.

The nebula 362, (M 33) discovered by Messier in 1764, is worth observing. It is 30 minutes in extent. According to Webb, it is very large, faint, and ill defined. A curious object only fit for low powers.

(*For Chart, see previous page*)

PERSEUS

PERSEUS (per′-sūs)—THE CHAMPION
(Face Northeast)

LOCATION.—Alpha Persei lies on a line drawn from β to γ Andromedæ, and is about nine degrees from the latter. A striking feature which assists in identifying the constellation is the so-called "Segment of Perseus," a curved line of stars beginning about twelve degrees below Cassiopeia, and curving toward the constellation Auriga.

This figure is composed of three stars. The star in the center is the second magnitude star, alpha Persei. It is flanked on either side by the two third magnitude stars γ and δ Persei.

The best way to locate the constellation, if you know the constellation Andromeda, is to look for the right-angled triangle formed by γ Andromedæ, β Persei (Algol) and alpha Persei. Algol marks the right angle.

Mythology

Perseus next
Brandishes high in heaven his sword of flame.

According to the ancient legend, Perseus was the son of Jupiter and Danæ. His cruel grandfather, Acrisius, placed the infant Perseus and his mother in a chest which he cast into the sea, hoping to destroy them. They were rescued by some fishermen and carried to Polydectes, King of Seriphus. Perseus was adopted by the King, and as he grew up became a great favorite. In order to prove his gratitude to his benefactor Polydectes, he determined to obtain the head of the Medusa to present to the King. Medusa was a terrifying creature who turned to stone all who gazed on her.

Mythology—*Continued*

The gods presented Perseus with the following useful gifts to aid him in his conquest of Medusa. Pluto gave him a helmet which rendered the bearer invisible, Minerva a shield that shone like a mirror, and Mercury bestowed on him winged sandals that enabled the wearer to fly swiftly through the air.

Perseus, thus equipped, sought out Medusa in a cave near Tartesus. Holding his shining shield so as to catch the reflection of the monster in it, he drew his sword, and with one powerful blow cut off her head. He flew back with it, and presented the trophy as a gift to King Polydectes, who was highly pleased with his exploit,

This deed made Perseus immortal, and won for him a place among the stars where he is honored for all time.

For the Naked Eye and Field Glass

Perseus is one of the few constellations that contains a naked eye object of great interest, the fluctuations in light of the short period Variable Star Algol, known to the Arabs as "the Demon Star." Algol is usually of 2.3 magnitude, but regularly, at intervals of 2 days and 20 hours and 48 minutes its brightness decreases. In 4½ hours it wanes to 3.5 magnitude. The star remains at minimum for 20 minutes, and then waxes to its original brightness.

The variations in the light of this star were first noted by Montanari in 1672. As early as 1782, Goodricke determined the star's period, and suggested that the fluctuations in its light were caused by some dark (or less luminous) body revolving about the star, and partially eclipsing its light from us. We now know this to be a fact. Professor Stebbins, using a selenium photometer, has obtained a highly accurate record of the light variations of Algol.

From the data obtained, Professor Russell has made the following deductions: The bright star is 1250 thousand miles in diameter. Its mass is three-eighths that of the sun. The fainter of the two stars is 1450 thousand miles in diameter. The centers of the two stars are just three million miles apart, and they revolve about one another in a nearly circular orbit in 68 hours, 49 minutes. The plane of the orbit is inclined about 7¾ degrees to the line joining Algol to the sun.

The eclipse we witness is partial, rather more than one-fourth of the diameter of the brighter star being obscured.

According to parallax determinations by Professors Adams and Joy, at Mt. Wilson, Algol is sixty light years distant. When on the meridian of New York City, Algol is only one-tenth of a degree from the zenith point.

(Continued on page 260.)

For the Naked Eye and Field Glass—*Continued*

The dates and time of minima are published in certain journals from time to time, and with the aid of this data anyone can observe the wax and wane of the light of this star *which can best be observed with the naked eye.*

It was in the neighborhood of Algol that a new star blazed out, February 22, 1901. It was discovered by Dr. Anderson of Edinburgh. Within a week it had attained a brightness equal to that of Capella, but by the end of the year it was no longer visible to the naked eye.

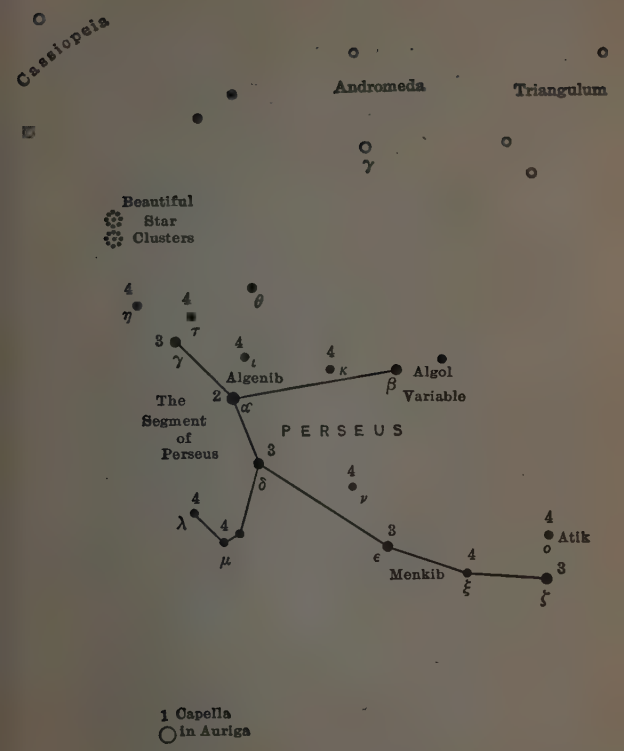
A noted meteor shower, called "the Perseids," radiates from this constellation. The meteors should be looked for August 11th and 12th. The radiant point is in the vicinity of γ Persei. These meteors are sometimes called "the Tears of St. Lawrence." They dart with great swiftness across the sky, and are yellow in color. They are known to be traveling in the same orbit as that of Tuttle's comet of 1862, and are probably associated with it. The average number of meteors in this shower visible per hour is sixty-nine.

For the opera or field glass, the double cluster beyond the star Persei, in the direction of Cassiopeia, is most noteworthy.

The region surrounding α Persei is also almost attractive. Sweep it with a field glass.

Alpha Persei never sets in the latitude of New York City (or, of course, in higher latitudes), where it just touches the horizon at its lower culmination.

PERSEUS


Cassiopeia
Andromeda
Triangulum
γ
Beautiful
Star
Clusters
4
η
4
τ
θ
3
γ
4
ι
Algenib
4
κ
Algol
β
Variable
2
α
The
Segment
of
Perseus
PERSEUS
3
δ
4
ν
4
λ
4
μ
3
ε
Menkib
4
ξ
4
Atik
o
3
ζ
1 Capella
in Auriga

For the Telescope

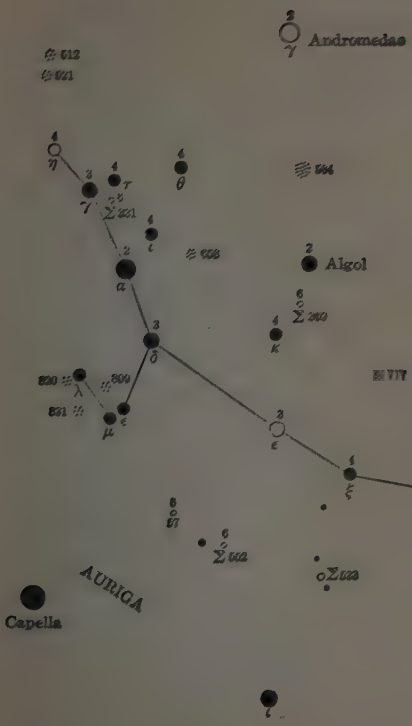
"Here again we enter upon one of the most splendid portions of the Galaxy."

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
η	4–8.5	28	300	White–Blue.
ε	3–8.3	9	9	
ζ	3–9	13	207	Multiple star.
57	5–6	114	168	Yellowish–Lilac.
Σ 552	6.3–6.4	9	114	Both white.
Σ 331	5.3–6.7	12	85	
Σ 369	6.5–8	3	28	Yellow–Blue.
9	4.2–9.5	20	237	

Alpha lies directly in the Milky Way, and in a rich field. It is 44 light years distant, and approaching at the rate of seven miles a second.

The famous double cluster, 512 and 521, is a wonderful object. It should be observed with low power. The writer considers this the finest cluster for a small telescope in the heavens. The field is simply sown with scintillating stars, and the contrasting colors are very beautiful.

The several other clusters indicated on the chart are good objects for a 3″ glass, particularly 584 (M34) which lies about half way between Algol and γ Andromeda.


Andromedae
Algol
Capella
AURIGA

PISCES

PISCES (pis′-ēz)—THE FISHES (Face Southeast)

LOCATION.—Pisces is an inconspicuous zodiacal constellation. It is represented by two fishes, each with a ribbon tied to its tail, the ends of the ribbons being joined together in a knot. The Northern Fish lies just below β Andromedæ. The so-called Western Fish is marked by a lozenge-shaped group of faint stars, and is situated a little below Pegasus.

The ribbons represented by streams of faint stars form a widespread "V," and terminate in a knot marked by the fourth magnitude star alpha Piscium, known to the Arabs as "El Rischa."

PISCES

Mythology

The Fishes shine one higher than the other.
ARATOS.

According to the old Greek myth, the beautiful Venus and her son Cupid were one day walking on the banks of the River Euphrates. Suddenly they saw approaching the terrible giant Typhon. Venus and Cupid hastily threw themselves into the river to escape the monster, and assumed the forms of fishes. To commemorate the fortunate escape from danger, Minerva placed the Two Fishes in the sky.

Astrologically, the constellation Pisces was considered an unlucky group of stars. In Egypt, in early times, the picture of a fish was considered odious.

The Babylonians, Syrians, Persians, Turks, and Greeks all regarded this constellation as representing two fishes.

The constellation is popularly thought to have taken its name from its coincidence with the sun during the rainy season, and the symbol for the sign ♓, to represent the two fishes joined.

The Fishes were considered the national constellation of the Jews, as well as a tribal symbol. A fish was the symbol of the early Christian faith.

It was in this constellation that Harding discovered the asteroid Juno, September 2, 1804.

For the Naked Eye and Field Glass

The "Circlet" representing the Western Fish, the position of which is indicated on the diagram, is an attractive naked eye sight. A stream of eight fourth and fifth magnitude stars connects it with alpha Piscium.

South of ω Piscium a few degrees, at the point on the Diagram marked with a star "✳", is the place which the sun occupies the first day of Spring. It is one of the two crossing places of the equinoctial colure, and the ecliptic, or sun's path.

Three distinct conjunctions of the planets Jupiter and Saturn took place in this constellation in the year 747 of Rome. In 1881 Jupiter, Saturn, and Venus were all grouped together in Pisces.

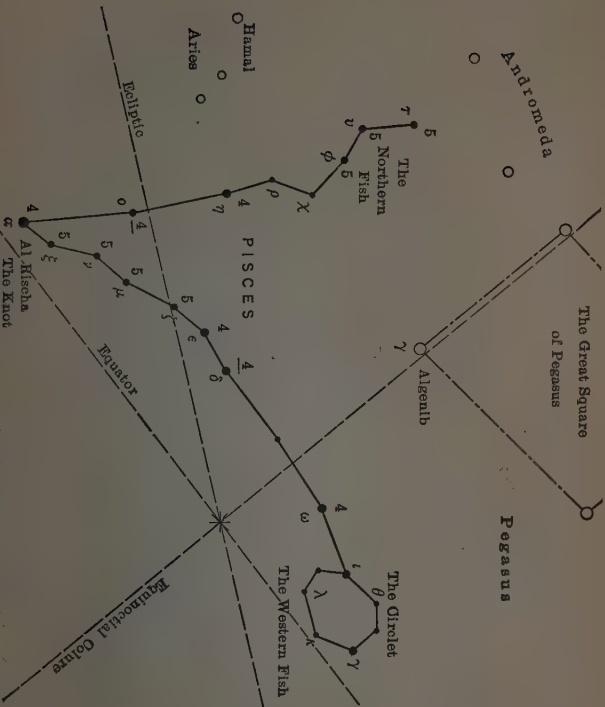
This constellation should be observed on a clear moonless night in order to trace out the faint stars it contains.

Alpha Piscium culminates at 9 P.M., December 7th.

The planet Uranus is in this constellation from 1929 to 1933 inclusive. It is just visible to the naked eye, but easy for a field glass, showing as a star of the sixth magnitude.

Refer to Nautical Almanac for exact position.

PISCES


The Great Square of Pegasus
Andromeda
Pegasus
Algenib
The Northern Fish
The Circlet
The Western Fish
PISCES
Hamal
Aries
Ecliptic
Equator
Equinoctial Colure
Al-Rischa
The Knot

For the Telescope

There are few bright stars in this region of the sky, but the constellation contains some interesting double stars. Data relating to a few of these are given below.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	4.3–5.2	2.5	320	Green–Blue. Difficult for 3 inch telescope.
ζ	5.6–6.5	24	64	A fine object.
ψ	5.6–5.8	30	160	No change noted in 130 years.
55	5–8.2	6	192	Yellow–Blue. A beauty.
65	6–6	4	299	
77	6–7	33	82	White–Blue.
35	6.2–7.8	11	150	White–Purple.
51	5–9	27	82	
38	7–8	4.7	237	Yellow–White.
42	6.8–11	31	344	Difficult for 3″ glass.

The fifth magnitude stars, ρ and 94 Piscium, form a splendid pair. The region about κ Piscium is particularly beautiful.

ξ Piscium is a spectroscopic binary.

The star ν Piscium is frequently occulted by the Moon. The occultations of stars by the Moon afford interesting observations. The list of stars occulted, with the dates, are given in the Nautical Almanac, which students should possess.

η Piscium is 58 light years distant.

ANDROMEDA
ARIES
γ Andromedae
γ Pegasi
Neb.
The Circlet

AQUARIUS

AQUARIUS (a-kwā′-ri-us)—THE WATER CARRIER
(Face Southwest)

LOCATION.—A line drawn from β Pegasi to alpha Pegasi, and prolonged as far again, ends just east of the so-called water jar of Aquarius. The water jar is a characteristic figure formed by a group of fairly bright stars making a "Y" shaped group, an equilateral triangle with a star in the center. The Arabs called these four stars a tent.

Mythology

> While by the Horse's head the Water Pourer
> Spreads his right hand.

The constellation Aquarius has been represented from remote times by the figure of a man pouring out a stream of water from an inverted jar. The constellation is an emblem of the rainy season, and the Egyptians thought that the floods on the River Nile were caused by the Water Carrier when, at setting, he dipped his jar into the river to refill it. The constellation is best seen from August to November.

The star alpha Aquarii bears the Arab name "Sadal Melik," which means "the fortunate star of the King." β Aquarii was known to the Arabs as "Sadal Suud," meaning "the luckiest of the lucky." The stars in this region appear to have been in great favor with the early astrologers in spite of the fact that they appeared at the inclement season of the year.

Few myths and legends connected with the constellation have come down to us. Aquarius has been identified with Deucalion, son of Prometheus and Clymene, and, according to a Grecian legend, Aquarius represents Ganymede, the favorite of the all powerful Jupiter. One day, so the story goes, as Ganymede was guarding his father's flocks on Mount Ida, he was suddenly transported to the sky where he became the cup bearer to the gods.

For the Naked Eye and Field Glass

The four stars forming the Water Jar make an attractive naked eye object.

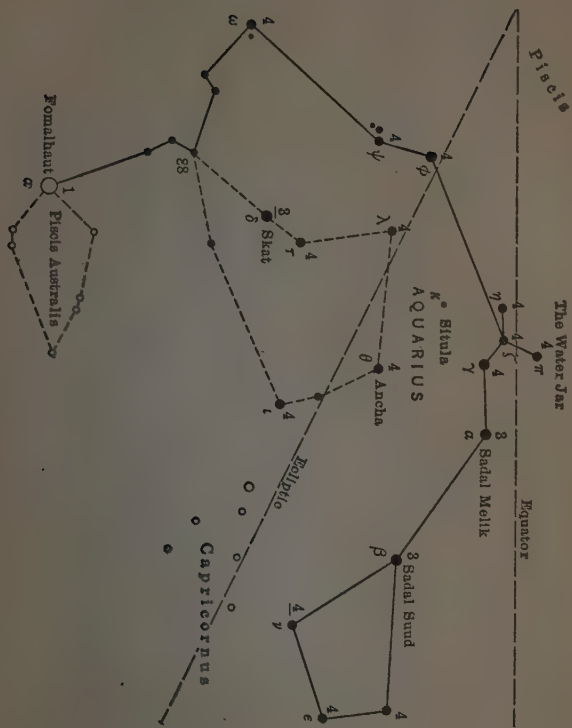
Sweep with the opera or field glass below the Water Jar down the sky in the direction of Fomalhaut where you will observe many pairs and triples. The ancients thought that these stars represented water trickling down the sky.

The water jar on the old charts is represented as inverted, and from it water streams down the sky into the gaping mouth of the Southern Fish, Piscis Australis. This stream is represented by pairs and three star groups of faint stars well seen with an opera glass. The ancients called this region of the sky "the Sea," and in this vicinity we find many aquatic creatures such as the Sea Goat, the Fishes, and the Whale.

A rude outline map of South America can be traced by connecting with lines the stars θ, λ, τ, δ, 88, and ι. See Chart. Some see a dipper in the western part of the constellation composed of the stars α, β, ν, and ϵ.

The star ζ is almost exactly on the celestial equator. λ is a red star, the most prominent of the first stars in the stream. A well known meteor shower radiates from the constellation known as "the η Aquarids" in May. They move swiftly, making evanescent streaks in the sky, and are visible late in the evening from the first to the sixth of that month.

One degree north of ι Aquarii is the place where the planet Neptune was discovered by Galle September 23, 1846, its position having been determined by Adams and Le Verrier.


The Water Jar
Piscis
Equator
Sadal Melik
Sadal Sud
κ Situla
AQUARIUS
Ancha
Ecliptic
Capricornus
Shat
Fomalhaut
Piscis Australis

For the Telescope

For the possessors of small telescopes the constellation offers many interesting and beautiful objects. The Chart indicates their location.

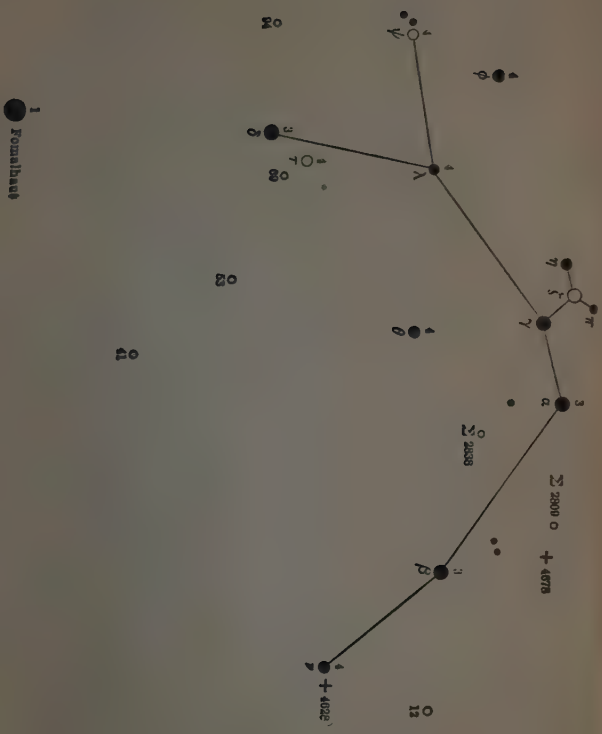
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ζ	4–4	3	317	Both white. Webb gives greenish white and pale yellow. Period 750 years.
12	5.6–7.7	3	190	
41	6–8	5	115	Yellow–Blue.
τ	6–9	30	112	White–Garnet.
ψ	4.5–8.5	49	312	Yellow–Blue. Fine contrast.
69	6–9	28	115	
94	5–7	13	347	Contrasting colors.
Σ 2809	6–8	31	163	
Σ 2838	6–9	21	185	Note stream of small stars.
53	6–6.5	7	308	

For the double star 107 Aquarii see Cetus.

Note the Nebula 4678, M 2, a beautiful planetary nebula discovered by Maraldi in 1764, a fine sight in a three-inch telescope. Streams of stars branch out from it taking the direction of tangents. Sir John Herschel compared it to a heap of fine sand, and considered it to be comprised of thousands of 15.0 magnitude stars.

Just west of ν Aquarii is another fine specimen of a planetary nebula, 4628, discovered by Herschel in 1782. Rosse calls it the "Saturn Nebula." It is moving toward the sun at the rate of 17 miles a second. Huggins disclosed the fact that it was a great mass of incandescent gas.

Webb gives 1624 years for the period of revolution of the double star ζ.


1 Fomalhaut
Σ 2838
Σ 2900
+ 4678
+ 4622

PISCIS AUSTRALIS

PISCIS AUSTRALIS—THE SOUTHERN FISH
(Low in the Southwest)

LOCATION.—The first magnitude star Fomalhaut (pronounced Fō′-mal-ō) lies almost due south of the Water Jar of Aquarius. It is the most southerly of the bright stars visible from the northern states, and as it is the only bright star in this region of the sky, the constellation is easily identified. The remaining few stars in the asterism are faint and so close to the horizon that they are seldom seen in these latitudes.

Fomalhaut is a 1.3 magnitude star of reddish hue, and distant from us 24 light years. It culminates at 9 P.M. on the 25th of October. In general type it resembles the star Sirius, and it rises almost simultaneously with Capella, the brilliant first magnitude star in the constellation Auriga. It has a 9.5 magnitude companion, blue in color, distant 72″, at an angle of 195°, a rather difficult object in a small telescope.

In 1896 Fomalhaut was discovered to have also a very faint companion 30″ away; visible only in a large telescope.

Fomalhaut is one of the four "Royal Stars" of astrology, the others being Regulus, Antares, and Aldebaran. It was the object of sunrise worship in the temple of Demeter at Eleusis in 500 B.C., and was regarded by the old astrologers as portending eminence and power. It was known to the ancients as "the First Frog."

Because of its isolation in the sky from neighboring bright stars, Fomalhaut is also known as the "Solitary One." Five thousand years ago the winter solstice was exactly above Fomalhaut, and then the star was known to the Persians as one of the four Guardians of Heaven.

Fomalhaut is drifting across the sky at a rate which will change its position among the stars an amount equal to the apparent distance across the full moon in the course of about 6000 years, a very rapid motion for so bright and distant a star.

(*For Diagram see p. 273*)

CAPRICORNUS

CAPRICORNUS (kap-ri-kôr'-nus)—THE SEA GOAT
(Face Southwest)

LOCATION.—A line drawn from alpha Pegasi through the stars ζ and θ of the same constellation, prolonged about 25 degrees, locates α and β Capricorni.

Capricornus, excepting Cancer, is the most inconspicuous of the zodiacal constellations. It contains two fairly bright pairs of stars that distinguish the constellation.

Alpha and beta Capricorni, the western pair, are each double stars. The former is a naked eye double.

Mythology

The Goat

Dim in the midst, but four fair stars surround him
One pair set close, the other wider parted.

ARATOS.

The constellation Capricornus has come down to us with its form unchanged through all the ages. On the old atlases, the Sea Goat appears with the head of a Goat and the tail of a Fish. The constellation is in the region of the sky known to the ancients as "the Sea."

The sign of the Goat was called by the ancients "the Southern Gate of the Sun."

The Goat which appeared on the Babylonian boundary stones, the most ancient of all our records, is identical with the figure we now identify as Capricornus.

According to Macrobius, the Chaldeans named the constellation "the Wild Goat." The reason the ancients used the figure of a goat to represent this constellation appears to have been because the sun, when it reaches the stars in this constellation, appears to mount the sky. The goat is always associated with climbing proclivities, and hence it was an appropriate symbol in this case. It is an interesting fact that our Tropic of Capricorn on the earth was so named when the southernmost point of the sun's path was in this constellation.

The fish tail attached to the goat was significant of the rains and floods of the winter season.

In Grecian mythology Capricornus was considered to be "the Gate of the Gods," and through

its stars the souls of men released at death were supposed to pass to the land of the hereafter.

"The Yoke" was another title borne by the constellation, a name suggested by the configuration of the three stars α, β, and δ.

The Romans believed that Capricornus was under the special protection of Vesta, and regarded the constellation with great veneration as having shed its influence on the birth of Augustus.

Burritt states that Capricornus is identified with the god Pan, or Bacchus, who with some other deities were one day feasting near the bank of the River Nile. Suddenly the dreadful giant Typhon came upon them. The assemblage immediately took flight, assuming different shapes in their efforts to escape. Pan took the lead and plunged into the river. and the part of his body which was submerged assumed the form of a fish, the part that was above the water took the form of a goat. To preserve the memory of the event, Jupiter made Pan into a constellation, in his metamorphosed shape.

The Greeks sometimes called this constellation "Pan." From this we get our word "panic."

Capricornus is connected in Egyptian astronomy with "the god of Waters," and is associated with the inundation of the Nile.

For the Naked Eye and Telescope

The star alpha Capricorni has a naked eye companion.

Beta Capricorni is a double star that can be observed with a field glass.

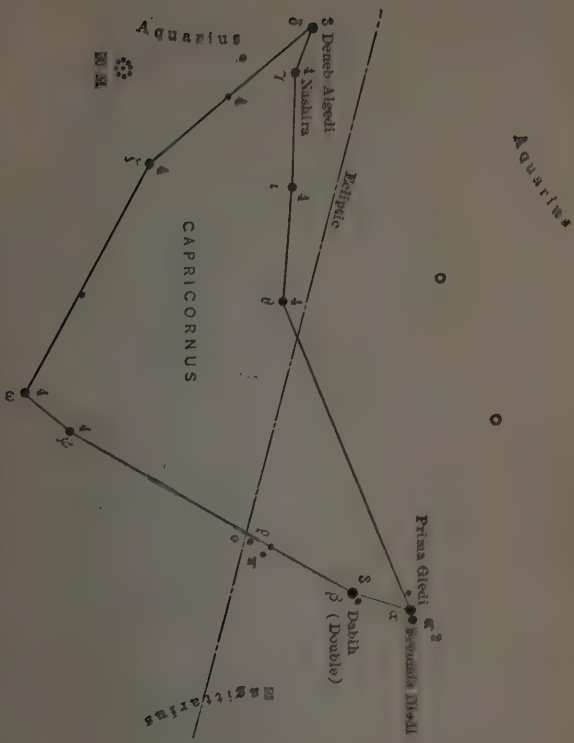
The stars of the constellation, connected with lines as in the Chart, form a figure resembling an inverted cocked hat.

The two stars in the head of the Sea Goat, alpha and beta Capricorni, are only two degrees apart. They are a conspicuous pair, and should attract the attention of an observer facing the southwestern sky during the early evening hours in Autumn.

The Chart indicates the position of the eastern pair of stars, which mark the tail of the Sea Goat. Twenty minutes east and three degrees north of δ Capricorni is the point in Aquarius calculated by Adams and Le Verrier for the position of the planet Neptune, and close to its observed position when it was discovered by Galle the night of September 23, 1846. The account of this notable discovery, the greatest achievement in pure mathematics on record, is to be found in the matter relating to the planet Neptune.

According to Flammarion, Chinese astronomers observed five planets in conjunction in the constellation Capricornus in the year 2449 B.C.

CAPRICORNUS



For the Telescope

There are several fine double stars in Capricornus that will prove of interest to the telescopist. The data concerning them follows, and the Chart indicates their location.

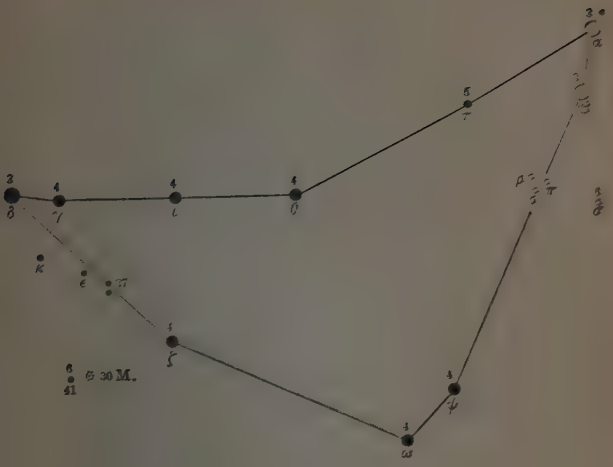
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	3–9.5 4–9	376	291	Naked eye double. Telescopic double double. Both yellow.
β	3.3–6.2	205	267	Orange–Blue. Field glass double.
ο	6.1–6.6	22	240	White–Bluish. A pretty pair.
σ	5.0–8.3	55	177	Orange–Blue.
π	5.1–8.8	5	146	Yellow–Bluish.
ρ	5.7–7.1	3	174	Yellow–Purple. Fine contrast.

Note the star cluster M 30. It lies closely preceding and a little north of the star 41 Capricorni. Webb describes it as "moderately bright, beautifully contrasted with an eighth magnitude star beside it." Use a power of about 70. The cluster can be resolved into stars with a five-inch refractor. According to Rosse, it is of a spiral form.

The stars π, ρ, and ο form a pretty triangle of fifth magnitude double stars.

A meteor shower known as the "alpha Capricornids" should be looked for from July 25th to August 4th. These meteors are generally bright, and move slowly leaving a long trail.

CAPRICORNUS



ARIES

ARIES (a'-ri-ez)—THE RAM (Face Southeast)

First from the east, the Ram conducts the year.

LOCATION.—The star α Arietis known to the Arabs as Hamal, and also bearing the title Arietis, is the most conspicuous star in the constellation. It is a star of 2.7 magnitude, and is situated about seven degrees south of alpha Trianguli. A line drawn from Polaris to γ Andromedæ and prolonged about twenty degrees ends close to alpha Arietis.

The constellation Aries contains only three conspicuous stars. These form an obtuse-angled triangle.

Mythology

Aries was known to the Arabs as "Al Hamal," the Sheep. It has also been called the "Prince of the Zodiac," "Prince of the Celestial Signs," and the "Leader of the Host of the Zodiac."

According to an ancient legend, this is the Ram into which Zeus, the most powerful of the gods of former times, changed himself, to escape the pursuit of the giants.

The most famous legend relating to this constellation links it with the heroic quest of the Argonauts in their search for the golden fleece. The story in brief is as follows:

Phrixus and Helle were the children of Athamas, King of Thessaly. Their stepmother treated them cruelly. Mercury took pity on them and sent a Ram with golden fleece to enable

them to escape from their wicked mother. They mounted on the Ram's fleecy back and were borne through the air over land and sea. Helle, unfortunately, fell from the Ram's back while they were crossing the strait dividing Europe from Asia. In memory of this sad event this strait was ever afterwards known as the "Hellespont," now, perhaps, better known as the "Dardanelles."

The poet Manilius has recorded this episode in the following lines:

> First golden Aries shines, who whilst he swam
> Lost part of's freight and gave to sea a name.

Phrixus landed safely at Colchis, at the eastern end of the Black Sea. In gratitude for his safe deliverance he sacrificed the Ram and gave its golden fleece to Aetes, the King of the Country, who hung it in the sacred grove of Ares, where it was guarded by a dragon that never slept.

Later on, the Argonauts, an assembly of heroes, organized an expedition to recover the golden fleece, and the intrepid Jason, one of their number, succeeded in obtaining it.

Jupiter placed the faithful Ram among the stars, where now it is a link in the golden girdle of the zodiac encircling the sky.

For the Naked Eye and Field Glass

Alpha Arietis is of the solar type, and has a proper motion of eight miles a second. It is approaching us at the rate of nine miles a second, and is forty light years distant from us. It lies near the moon's path, and is one of the stars from which longitude is reckoned.

The star γ Arietis, known to the Arabs as Mesarthim,

was one of the first double stars discovered. It was accidentally discovered by Robert Hooke in 1664 when he was following a comet.

Aries is the constellation of Spring, or was, 2000 years ago. It now rises two hours later, and meets the sun a month later than formerly, owing to the precession of the equinoxes. The zodiacal sign Aries, which once coincided in position with the constellation, is now located in the constellation Pisces to the westward.

The Arab star name Sheratan, beta Arietis, means "the Sign."

The pair of stars, beta and gamma Arietis, are one instance out of many where conspicuous stars form pairs, the brighter of the two stars lying generally to the East.

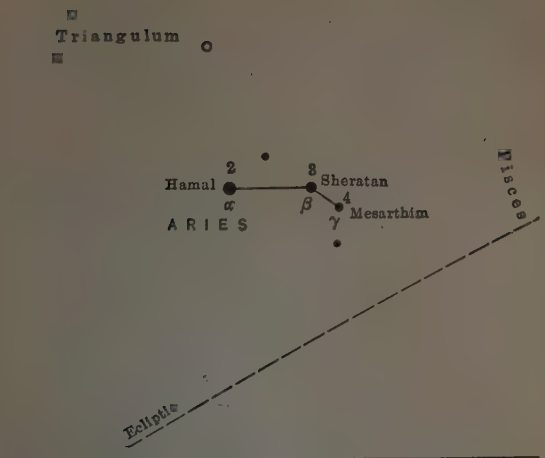
The planet Jupiter is in Aries during the latter part of 1929.

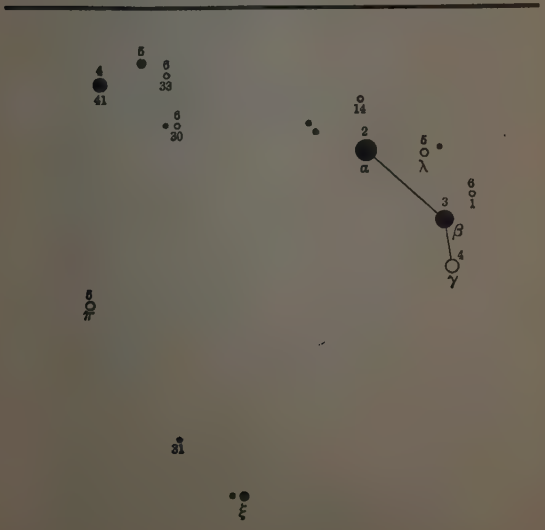
For the Telescope

The telescopic objects of interest in the constellation are the following double stars, the chart indicating their location:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
γ	4.2–4.4	8	360	White–Pale gray.
λ	5–8	38	45	White–Blue.
14	5–9–7	93	36	Triple
		106	278	White–Blue–Lilac.
30	6.6–7.4	39	273	Yellow–Gray. Very fine.
33	6–9	28	0	Topaz–Sapphire.
π	5–8–10.5	3	117	Triple
		25	110	
1	6–7	2.6	170	

ARIES


Triangulum
2
Hamal
α
3
Sheratan
β
4
Mesarthim
γ
ARIES
Pisces
Ecliptic


4
41
5
6
33
6
30
14
2
α
5
λ
6
1
3
β
4
γ
6
π
31
ξ

CETUS

CETUS (sē′-tus)—THE WHALE (Face Southeast)

LOCATION.—A line drawn from Polaris to δ Cassiopeiæ, prolonged two and one-third times its length, reaches the center of the constellation. Cetus lies just below Aries and the Triangle. A clearly defined pentagon of fairly bright stars about twenty degrees southeast of Aries marks the head of the beast.

The brightest star in the constellation is alpha, of the second magnitude. It is about fifteen degrees east of the star Al Rischa, alpha Piscium.

Mythology

With gills pulmonic breathes the enormous whale.
DARWIN.

Cetus is the largest of the constellations, and an extremely ancient one. The best known legend that has come down to us relating to it is from the Greeks and connects it with the story of Perseus and Andromeda. It will be found under the mythological references in the chapter on Andromeda.

In the 17th Century, Cetus was considered to be a symbol of Jonah's Whale, and also Job's leviathan.

A popular name for the constellation is "the Easy Chair," as the arrangement of its stars suggests to the imaginative a reclining chair.

Brown tells us that Cetus signified "the chaos of the deep" to the Babylonians. Aratos called it "the Dusky Monster."

It has been suggested that it may represent the ferocious Tiamat of the early Chaldean myths.

For the Naked Eye and Field Glass

The chief object of interest in the constellation Cetus is the long period Variable Star omicron Ceti, known as Mira, "the Wonderful Star." Mira was discovered by Fabricius August 13, 1596, and has been closely observed since that date. It varies in brightness from a ninth magnitude star at minimum, to a third or fourth magnitude star at maximum. In 1779 Herschel observed it nearly as bright as Aldebaran, the first magnitude star in Taurus. Four years later it was invisible even in his telescope. Its period is 334 days, that is, the elapsed time between successive maxima or minima. Its period and range are highly irregular, and the causes of these irregularities are unknown and present a baffling problem.

According to a parallax determination by Professor Mitchell, one of our greatest authorities on the subject, Mira is 220 light years distant.

Mira remains at maximum about ten days, then its light slowly wanes for eight months, after which it rises to maximum, sometimes very rapidly. At minimum Mira is only one one-thousandth of its maximum brightness. The star is distinctly red in color, as are most of the long period Variables, and it is a Giant Star.

The measurements of the star recently made at the Mount Wilson Observatory reveal the fact that Mira has a diameter of 250,000,000 miles, somewhat greater than the diameter of Betelgeuze in Orion. Antares, in the Scorpion, alone surpasses Mira in size of all the stars that have as yet been measured.

Maxima of Mira will occur again at approximately the following dates, according to calculations made by Mr. Leon Campbell, of the Harvard College Observatory: June 22, 1930; May 20, 1931; and April 19, 1932. For several months before and after maximum, Mira can be observed with the naked eye or a field glass. Any person desiring to contribute data of value to Science should observe this star, and make estimates of its bright-

(Continued on page 291.)

For the Naked Eye and Field Glass—*Continued*

ness from night to night. Charts for the purpose can be obtained of the Chart Committee of the A.A.V.S.O., Harvard College Observatory, Cambridge, Mass. The writers will be glad to furnish full information.

Spectroscopically Mira is also remarkable. Its spectrum is crossed by heavy bands due to the presence of the vapor of titanium oxide. Hydrogen shines very brightly near the maximum, while at minimum many of the characteristic low-temperature lines of the metals are bright.

Professors Pettit and Nicholson have measured the heat which is received from Mira, and find that, although the light may diminish a hundredfold at minimum, the heat falls off only to about one-third.

Even at maximum, Mira gives but about one-tenth as much light in proportion to its heat as does a white star like Vega, while at minimum the ratio of light to heat may fall as low as one to five hundred.

From a study of the star, Professor Russell concludes that its surface brightness even at maximum is very low. At minimum the computed temperature is 1600°, hardly enough to melt steel. It has been calculated that the heat radiation of Mira is about one thousand times that of the sun. Its bulk is twenty-seven million times the sun's.

It is apparent that Mira, to quote Professor Russell, is in an extremely early stage, one of the youngest stars we know of, not in years but in its state of development.

Radial velocity measures show that Mira is approaching us when faintest, and receding when brightest, as if it were moving in an orbit. According to Professor Joy's calculations, this orbit would be 35 million miles in diameter. Perhaps the most remarkable fact concerning this wonderful star is that it is hottest, not when it is rising in brilliancy, but when it is fading, a fact that presents an interesting problem in astrophysics.

October 19, 1923, Professor Aitkin of the Lick Observa-

(*Continued on page 292.*)

For the Naked Eye and Field Glass—*Continued*

tory, discovered that Mira had a companion of a bluish color, distant 1″.01, in position angle 132.3°. This observation confirmed Professor Joy's mathematical deduction that the star was a double. A similar example of theoretical deductions, that were confirmed by later observation, occurred in the case of the discovery of the companion of Sirius.

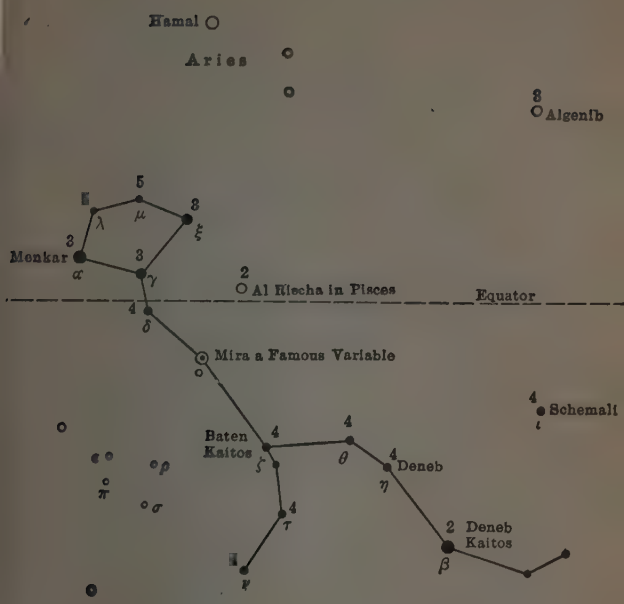
It seems only fitting that the facts relating to this famous star should be given in some detail, as Mira is one of the most remarkable stars in the heavens, and of the greatest interest to astronomers. "Three hundred years have only added to the mysteries associated with its behavior."

τ Ceti is one of our nearest neighbors, at a distance of 10.3 light years.

According to recent measures for parallax by Professor Mitchell, alpha Ceti is 148 light years distant, and γ Ceti 77.5 light years from our system.

Webb says: "The star alpha is now fainter than beta Ceti. One or both may have changed."

CETUS



Hamal
Aries
3
Algenib
5
λ
μ
3
ξ
3
Menkar
α
3
γ
2
Al Rischa in Pisces
Equator
4
δ
Mira a Famous Variable
4
Schemali
ι
Baten
Kaitos
4
ζ
4
θ
4
Deneb
η
ρ
π
σ
4
τ
2
Deneb
Kaitos
β

For the Telescope

The constellation Cetus contains many double stars of interest to the possessors of small telescopes.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
ζ	3.5–6	185	41	Optical double.
γ	3.7–6.2	2.5	290	Yellow-Blue. Finest double in this region.
26	6–9	16	252	Topaz-Lilac.
37	5–7	50	331	
66	5.7–7.8	16	230	Yellow-Blue.
Σ 30	6.8–8.5	20	45	Yellow-Bluish.
16	6–8.5	65	289	
Σ 150	7–8	30	105	A fine double.
Σ 274	7–7.5	13	218	
84	6–9	5	334	
ΣI 6	7–7	81	162	
167	5.8–7	6	138	In Aquarius. Colors fine.

χ has a seventh magnitude companion.

The Nebula 138 was discovered by Caroline Herschel in 1783. It is described as being long, narrow and bright.

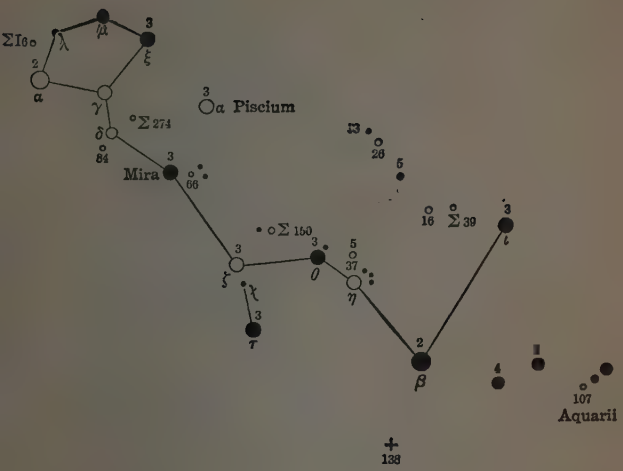
Alpha Ceti, a second magnitude star, yellow in color, has a blue companion of 5.5 magnitude in the same field. Use a low power. It is not a true double.

η Ceti is another wide double, 3.5–9.5. Distance 225″, Angle 305°.

Of course observe Mira and follow it through its changes.

About one degree southeast of δ Ceti, and not far from the small double 84, is the faint spiral nebula M 77, unfortunately omitted from the chart. The shift of the lines in the spectrum of this nebula indicate a speed in recession from us at the amazing velocity of nearly 690 miles per second. However, as *all* of the *distant* spirals show apparently terrific velocities, increasing in proportion to their distances from us (up to speeds of 2,400 miles per second) and *all* in recession, there seems reason to suspect that the shift of their spectrum lines is from some other cause—possibly "curvature of space," a tenet of the Relativity Theory.

CETUS



ΣI6
λ
μ
3
ξ
2
α
γ
3
α Piscium
Σ 274
δ
84
Mira
3
66
13
26
5
16
Σ 39
3
ι
Σ 150
3
ζ
3
θ
5
37
η
χ
3
τ
2
β
4
107
Aquarii
138

N.
S.
E.
W.
URSA MAJOR
DRACO
CYGNUS
Deneb
URSA MINOR
The Pointers
LEO MINOR
LEO
Regulus
The Sickle
North Pole
Polaris or Pole Star
CEPHEUS
CASSIOPEIA
PEGASUS
The Great Square of Pegasus
The Circlet
The Water Jar of Aquarius
ANDROMEDA
The Head of Hydra
CANCER
Bee Hive
ECLIPTIC
Procyon
CANIS MINOR
Pollux
Castor
GEMINI
LYNX
Solstitial Colure
Capella
The Kids
AURIGA
PERSEUS
Algol (Var.)
Over-head
TRIANGULUM
ARIES
PISCES
ECLIPTIC
Equinoctial Colure
Nath
TAURUS
THE PLEIADES
The Hyades
Aldebaran
MONOCEROS
Betelgeuze
ORION
Bellatrix
Equator
Sirius
CANIS MAJOR
Rigel
Mira (Var.)
CETUS
LEPUS
ERIDANUS
Phaet
COLUMBA

THE CONSTELLATIONS OF WINTER

The folded map opposite shows the principle stars visible from Latitude 40° N. at:

9:00 P.M. January 1st

9:30 Dec. 22	8:30 Jan. 7
10:00 Dec. 14	8:00 Jan. 14
10:30 Dec. 7	7:30 Jan. 22

The Times are Eastern Standard.

Chart held in this position depicts Southern sky. Quarter turns of the book from left to right give correct views successively of Eastern, Northern and Western sky.

TAURUS

TAURUS (tau′-rus)—THE BULL (Face Southwest)

LOCATION.—The constellation Taurus contains the well known and unmistakable star cluster known as "the Pleiades," situated in the right shoulder of the Bull.

A "V" shaped group of stars, "the Hyades," is just to the southeast of the Pleiades in the face of the Bull, a beautiful coarse cluster, in the midst of which gleams the ruddy first magnitude star Aldebaran which marks the Bull's eye.

Aldebaran is at the apex of a large triangle formed by Capella in Auriga, and alpha Persei, and equally distant from them both.

The star β Tauri, called by the Arabs "Nath," is common to the constellations Taurus and Auriga. It marks the tip of one of the Bull's horns.

TAURUS

Mythology

I mark stern Taurus, through the twilight grey.
TAYLOR.

The constellation Taurus is beyond question one of the oldest of the ancient star groups. Over 4000 years ago the Bull marked the Vernal Equinox, the position in the sky occupied by the sun the first day of Spring. This yearly occurrence was the cause of great festivals and celebrations throughout the ancient world.

Centuries before the time of Christ, the Bull was worshipped in Persia and Babylon. The Egyptians considered Taurus an emblem of immortality.

The familiar Greek legend relating to Taurus is as follows: Europa, the beautiful daughter of the King of Phœnicia, was beloved by Jupiter. In order to be near her he assumed the shape of a snow-white Bull, and as Europa was gathering flowers in a field, he approached her.

Europa, attracted by the beautiful animal, stroked his snowy coat, and finally seated herself on his back. The bull immediately dashed away with her, and bore the terrified maiden safely to Crete, where Jupiter revealed himself and won Europa for his bride.

There is a beautiful painting by the noted artist, Paul Veronese, hung in the Ducal Palace in Venice, depicting Europa seated on the bull.

THE PLEIADES

Mythology

The group of sister stars, which mothers love
To show their wondering babes, the gentle seven.

BRYANT.

Volumes have been written about this famous cluster. The Pleiades are mentioned in the Bible in the lines: "Canst thou bind the sweet influences of the Pleiades."

We find the Pleiades mentioned in China over 2000 years before Christ.

The Egyptians, Aztecs, Japanese, and Hindus all worshipped these stars, and they were universally regarded with wonder and admiration.

The festivals of All Hallows Eve, All Saints' Day, and the memorial services to the dead held in many lands in the Fall of the year, are all associated with the Pleiades. The culmination of these stars at midnight was the occasion of services of great solemnity among the ancient Peruvians. It is thought that these universal memorial services commemorate a great cataclysm that occurred in ancient times, causing a great loss of life.

In mythology, the Pleiades were the seven daughters of Atlas and Pleione. It is said that they were placed in the sky because of their many fine qualities, but another story relates that they were so honored because of their grief at the task imposed on their father Atlas, of holding up the world on his shoulders.

The attractive names of the sisters are as follows: Alcyone, Merope, Celæno, Taygeta, Sterope, Electra, and Maia. The Pleiades have been regarded as representing Doves, Jupiter being thought to have changed them into this form to enable them to escape the attentions of Orion.

The coarse cluster of stars in Taurus called the Pleiades has attracted universal attention since remote times. Astronomers have of late years discovered many facts of interest relating to the cluster.

The distance of the Pleiades from us is estimated to be about 350 light years. The diameter of the cluster is calculated to be about 35 light years.

The remarkable fact has been discovered that the whole cluster is enveloped in nebulosity of vast extent, which appears to shine by reflected light. What we see is apparently an opaque cloud, faintly illuminated by the light of the suns in this neighborhood. The extent of this vast cosmic cloud enveloping the Pleiades may be gathered from the plate facing page 42.

Six stars in the Pleiades can be seen with the naked eye. More than one hundred can be seen with a small telescope. On a photographic plate of the region two thousand stars have been counted.

There is an almost universal legend that, originally, there were seven naked eye stars in the group, and that one has been lost. This myth of the "Lost Pleiad" has given rise to an immense amount of folk lore to account for the missing star. The student will find a wealth of material on the subject in the works on stellar folk lore. The peculiar character of the spectrum of Pleione, one of the Pleiades, has led Professor Pickering to the belief that it formerly shone with a temporary brilliancy, and that this star is the lost Pleiad.

The astronomer Maedler considered that Alcyone, the brightest star in the cluster, was the central sun of the universe. This opinion is not supported by orthodox astronomers to-day.

It has been discovered that the stars in the Pleiades are moving together in the sky like a flock of birds. They are converging toward a definite location in the heavens, which is about five degrees east of Betelgeuze in Orion. Professor Trumpler has discovered that a number of faint stars near the Pleiades partake of the same rate of speed and direction of flight as the Pleiades, showing that they are a part of the cluster.

THE HYADES

Mythology

Who hears not of the Hyades, sprinkling his forehead o'er?
ARATOS.

This beautiful star cluster has from ancient times been associated with the rainy season, perhaps because of the fact that these stars rise in the Fall of the year, the season of inclement weather. They are often referred to as "the rainy Hyades." The Arabs knew this group as "the Little She Camels."

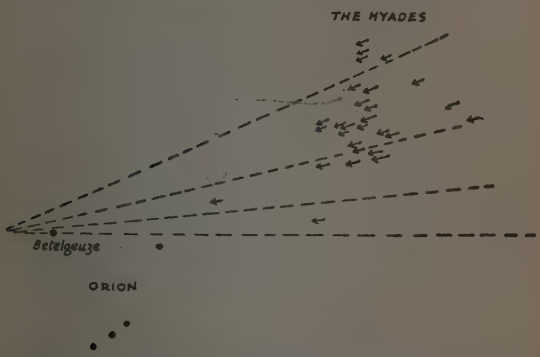
The Hyades were supposed to be the five daughters of Atlas, King of Mauretania, and half-sisters of the Pleiades. They were changed into stars on account of their grief for the death of their brother Hyas, who was killed by a wild boar. The fact that they shed such copious tears may be the reason for the watery reputation which they have always borne.

According to another story, the Hyades were

the nurses of the infant Bacchus, and on their death they were rewarded for their faithful service by being placed in the starry skies.

The Hyades cluster has received much attention from astronomers in the last few years. The stars comprising the group are red or yellow in color, and giants in size.

It has been estimated that the cluster is 140 light years distant. Its stars are receding from our system, and three of the brightest stars in the group move at the rate of twenty-five miles a second. These stars are estimated to be fifty to one hundred times brighter than the sun.



Direction of Proper Motion of the Stars in the Hyades Cluster

According to Professor Boss, about forty stars in the cluster partake of a common proper motion, and are moving toward the same goal as the stars in the Pleiades mentioned above.

It is to be noted that Aldebaran's motion is independent of the other stars in the Hyades, and that it is moving in a different direction from them.

For the Naked Eye and Field Glass

Many consider the cluster of the Pleiades the most attractive of all the star groups. In an opera or field glass they present a charming appearance. In the Hyades an opera glass reveals many attractive pairs of stars.

See previous pages of this chapter for description of these Clusters.

The Ecliptic (the path of the planets) passes a little south of a point midway between the Bull's horns.

The feature star of the constellation is Aldebaran. It bears an Arab star name signifying "the Follower," so called as the star rises after the Pleiades.

The mean of seven authoritative parallax determinations indicates that Aldebaran is 57 light years distant from us.

The diameter of Aldebaran, as computed by Professors Michelson and Pease, is thirty million miles. It is estimated to be ninety times brighter than the sun.

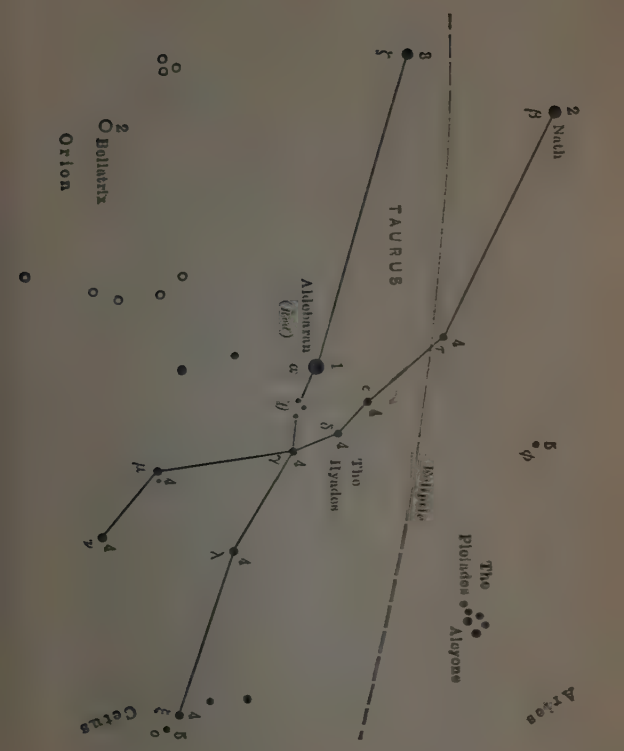
Aldebaran is receding from us at the rate of 34 miles a second, but as mentioned before, its proper motion is in a direction different from the other stars in the Hyades cluster.

θ^1 and θ^2 are a naked eye pair. Attractive objects in field or opera glass. Magnitudes 3.6 and 4.

σ has a naked eye companion.

The planet Jupiter is in Taurus during the last part of 1929 and all of 1930.

TAURUS



Nath
TAURUS
Aldebaran
(Rest)
The Hyades
The Pleiades
Alcyone
Bellatrix
Orion
Cetus
Aries

For the Telescope

Taurus is one of the most interesting of all the constellations. It contains a large number of beautiful double stars, a few of which are cited below.

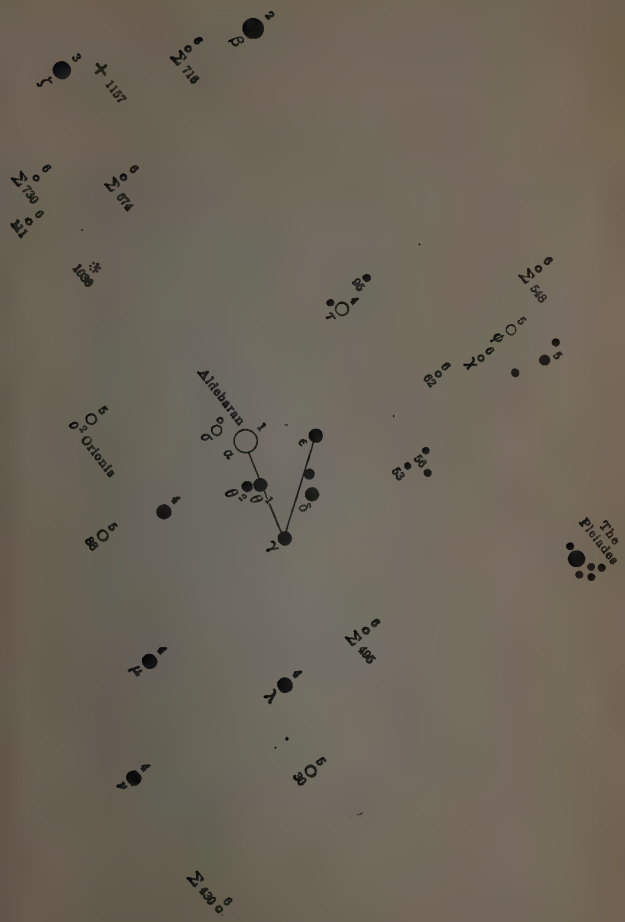
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
Σ 430	6–9–9.5	26	55	A Triple.
		39	302	
30	4.5–9.6	9	58	Emerald–Purple.
φ	5.1–8	50	250	Red–Blue.
Σ 674	6–9	10	147	
Σ 716	6–7	5	200	A beautiful pair.
τ	4.3–7	63	213	White–Blue.
Σ 548	6–8	14	35	
Σ 495	6–8.8	3	216	
χ	5.7–7.8	19	25	
111	5.7–8.2	75	271	
Σ 730	6.5–7	10	142	
62	6–8	28	289	A fine field.
88	4–7.5	69	299	
O^2 58	5–7–9	39	304	Triple in Orion.
		54	88	A beauty.

Aldebaran has a tenth magnitude companion: D. 114″, A. 35°.

Alcyone, the brightest star in the Pleiades, is a quadruple star and a very beautiful object.

The "+" shows the location of the famous "Crab Nebula," the first nebula discovered by Messier. It takes a powerful glass to bring out any detail.

Note the field about the star ζ Tauri.


Aldebaran
The Pleiades
Orionis

ORION

ORION (ō-rī′-on)—THE GIANT HUNTER (Face South)

LOCATION.—Orion is considered the finest constellation in the heavens. There is little difficulty in identifying it. A line drawn from β Tauri to ζ Tauri (the stars marking the tips of the Bull's horns), prolonged fifteen degrees, strikes the red first magnitude star Betelgeuze (α Orionis).

Betelgeuze is at the northeast corner of a conspicuous parallelogram of stars formed by the stars α, γ, β and κ Orionis.

Rigel, a star of the first magnitude, is diagonally opposite Betelgeuze in this figure.

The Belt of the Hunter, marked by a row of three second magnitude stars in a line three degrees long, lies within the parallelogram. They present a striking appearance.

About nine degrees west of Bellatrix (γ Orionis) are eight faint stars in a curved line. These mark the lion's skin held in the Hunter's left hand.

Below λ Orionis are two stars forming with it a small triangle. This group marks the head of Orion.

Orion rises in the early evening about December 1st and sets in the western sky the middle of April.

The mythological figure of this giant Orion is shown on the cover design.

Mythology

Behold Orion rise,
His arms extended measures half the skies.

MANILIUS.

Orion is described by Homer as "the tallest and most beautiful of men." It is said that he claimed superiority over every creature on the earth. The Gods, to punish his conceit, sent a scorpion to attack him; the creature bit Orion in the foot and caused his death. At Diana's request, Orion was transported to the sky, but placed opposite the scorpion so that it could never harm Orion again.

Another legend relates that Orion fell in love with Merope. He attempted to elope with her, but her father interfered and was so incensed at Orion that he caused his eyes to be put out. The blind giant wandered aimlessly about till he came to the forge of Vulcan. Vulcan took pity on him and had him taken to the top of a high mountain. Here Orion faced the rising sun and his sight was restored.

Orion was held in dread by sailors, as the presence of the constellation in the sky presaged stormy weather.

There is a vast amount of folk lore and mythology relating to this constellation.

For the Naked Eye and Field Glass

Orion is the most brilliant of the constellations and always delights the eyes of all beholders.

The most remarkable object in Orion is the Great Nebula. Volumes have been written concerning it, but a brief account must suffice here. The nebula is located in the sword of Orion, marked by the star θ Orionis. The nebula is a stupendous mass of gas in a state of violent agitation, a gigantic whirlpool.

Even when viewed with an opera or field glass the star Theta Orionis appears to be enveloped in a haze which indicates the presence of the great nebula which is a glorious and wonderful sight in a large telescope. Words fail utterly to describe its beauty.

According to Kapteyn, the nebula is 600 light years distant. The bright part is about one parsec, or 3.26 light years, in diameter. Professor Russell tells us that the mass of the nebula is 10,000 times that of the sun. On the average it is receding from us at the rate of 17.5 kilometers a second.

The first mention of the Orion Nebula is by a Swiss Jesuit, named Cysatus, in 1618. He used it, without suspecting its character, as a term of comparison for the comet of that year. The nebula has been under effective observation for 250 years.

This nebula, it should be noted, is quite differently constituted from the spiral nebulæ, like the great one in Andromeda. The spirals are vast systems of suns, similar to our Galaxy, while the Orion nebula is a mass of luminous gas.

(Continued on page 311.)

For the Naked Eye and Field Glass—*Continued*

The most interesting star in Orion is the ruddy Betelgeuze, known as "the Martial Star." It is the first star whose diameter was measured. This remarkable achievement was brought about by the use of the interferometer, a marvelous instrument invented by Professor Michelson. The instrument was attached to the great 100-inch reflector at the Mt. Wilson Observatory December 13, 1920, and the diameter of the star Betelgeuze was measured by Professors Pease and Anderson. The diameter of the star was found to be 215 million miles. This result confirmed the deductions of Professors Russell and Eddington, made two years before, that Betelgeuze was a giant star. In volume, Betelgeuze is 27 million times as great as the sun, and its mass fifty times that of the sun. It is estimated that the star is 1600 times as bright as the sun. Betelgeuze is 240 light years distant. The star is a Variable, a fact discovered by Sir John Herschel in 1836.

Rigel has the distinction of being the brightest star we know of, not to our eyes but in reality. It is estimated to be 14,000 times brighter than the sun. It is calculated that the diameter of Rigel is 35 times that of the sun, which is 866,000 miles. Rigel is 460 light years distant, and is receding from our system at the rate of 14 miles a second.

One of the most extraordinary objects in the sky is located a little south of the star ζ Orionis. It is a so-called "Dark Nebula," a jet black cosmic cloud in the form of a sharp cut silhouette of a horse's head. A remarkable photograph of this object was taken by Professor Duncan with the 100-inch Hooker telescope at Mt. Wilson.

The Belt stars in Orion have attracted universal attention since the dawn of history. They point up the sky to Aldebaran in Taurus, and down to Sirius in Canis Major.

(Continued on page 312.)

For the Naked Eye and Field Glass—*Continued*

Flammarion called this region "the California of the Sky." No other constellation contains so many bright stars.

The celestial equator passes nearly through the star δ Orionis.

The star θ Orionis is a quadruple star, the four stars forming a trapezium which lies in the heart of the nebula. Observe it with a field or opera glass.

Professor Shapley tells us that within three degrees of θ Orionis there are more than one hundred faint Variable Stars. These stars are dwarf stars, contrary to the type of most Variables, which are giants. It may be that these Orion Variables present a new type, and that their variations in brightness arise from the relative movement of stars and nebulosity.

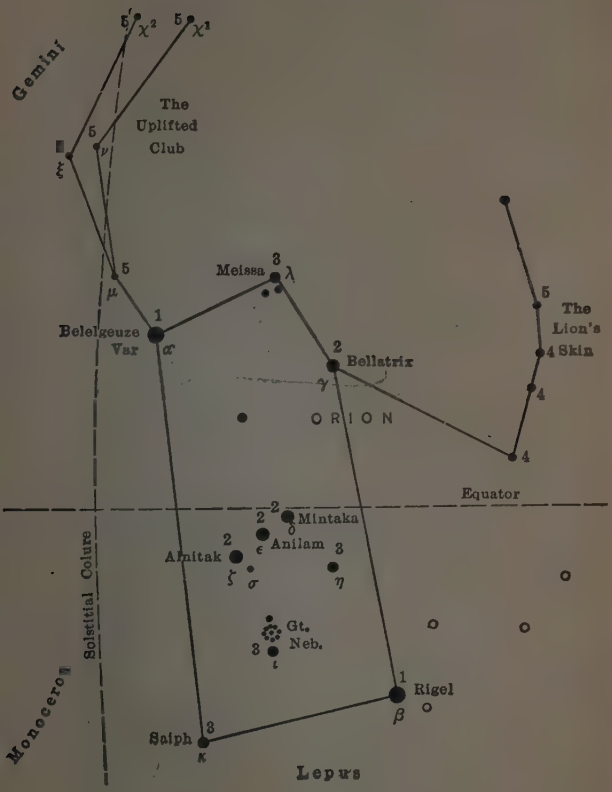
Spectroscopically, most of the brighter stars of Orion—Betelgeuze excepted—are of the same class (B type); indeed stars of this spectral class are known as of the "Orion type."

There is good reason to believe that, despite their great separation, these stars form a vast cluster.

Note the contrasting colors of the stars α and β Orionis.

A well known meteor shower occurs each year in this region, known as "the Orionids." The meteors should be looked for the night of October 19th. A line drawn from Rigel to Betelgeuze, prolonged half its length, locates the radiant point of the shower.

ORION


Gemini
The Uplifted Club
Meissa
Belelgeuze Var
Bellatrix
The Lion's Skin
ORION
Equator
Mintaka
Anilam
Alnitak
Gt. Neb.
Rigel
Saiph
Lepus
Solstitial Colure
Monoceros

For the Telescope

Webb cites over seventy double stars in Orion. A partial list is given below. The constellation offers a wealth of interest and beauty for the telescopist.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
δ	2.5–7	53	360	White–Blue.
ι	3–7	11	142	Fine field.
λ	3.7–5.6	4	43	Yellow–Red. Sweep here.
Ψ	5.5–11	2.8	322	Difficult for 3″ glass.
ρ	5–8.5	7	62	Yellow–Blue.
ζ	2–4.2	2.8	158	Yellow–Blue.
Σ 747	5.5–6.5	36	223	
Σ 816	6.2–8.7	4	289	
Σ 627	6.5–7	21	260	A splendid pair.
m	5–5.1	32	28	
o^2	5–7–9	39	304	A triple.
		54	88	
Σ 795	6–6	1.7	200	Excellent test.
Σ 750	6–8	4	59	
Σ 855	6–7	29	113	

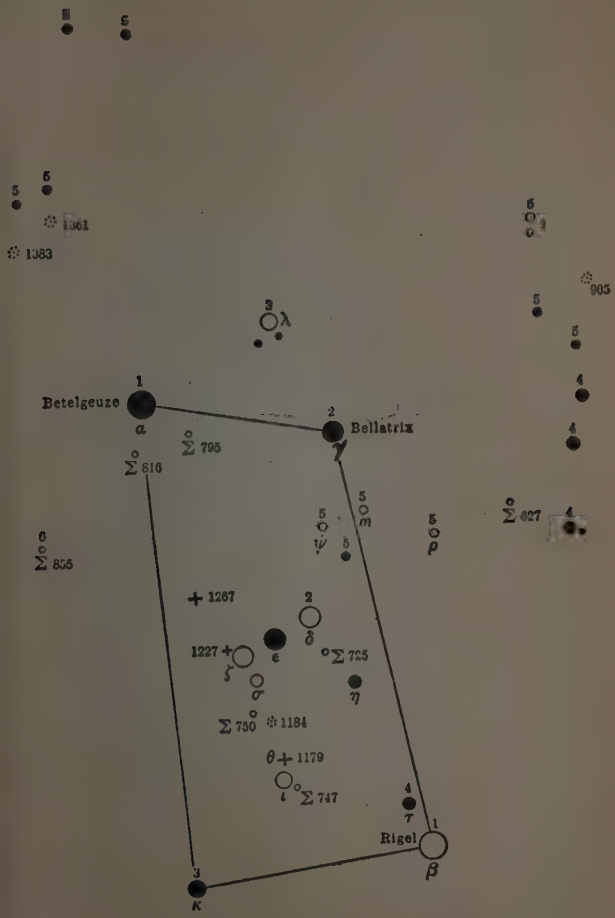
Σ 725 has an eleventh magnitude companion.

σ is a beautiful multiple star, many colors contrasted. The magnitudes are 3.9, 5, 9.5, 6.8, 6.3. Three of the components are visible in a 3″ glass.

θ is a quadruple star, the four stars veiled in the nebulosity. Try for the ninth magnitude companion of Rigel, distance 9^{11}, position 200°. Smythe claims it is a test for a 4-inch refractor.

Of course, observe the nebula. An excellent way to do this is to sight the telescope *in advance* of the nebula and allow this to creep into the field. A far better idea of the extent of the luminosity can be obtained by using this method. Only a long exposure photograph can show the true vastness of this wonder of the skies. See frontispiece.

ORION



Betelgeuze
Bellatrix
Rigel
1361
1383
905
Σ 795
Σ 816
Σ 627
Σ 855
1267
1227
Σ 725
Σ 750
1184
1179
Σ 747

LEPUS

LEPUS (lē'-pus)—THE HARE (Face South)

LOCATION.—Lepus, the Hare, crouches under Orion's feet. Four fairly bright stars in the constellation form an irregular and conspicuous quadrilateral. A few degrees south of Rigel are four faint stars that mark the ears of the Hare. The curved line of three stars formed by θ, η and ζ Leporis are in the back of the creature.

Lepus is about eighteen degrees west of Canis Major.

Mythology

> Under Orion's feet, mark too the Hare
> Perpetually pursued.
>
> ARATOS.

Classical writers are much in doubt regarding the history of this constellation.

According to Brown, the Hare is a reduplication of the Moon. An astonishing amount of folk lore connects the Moon with the Hare.

As the constellation Lepus sets, the Crow rises, which fact accounts for the ancient belief that the Hare detested the call of the Raven.

The Arabs once regarded this constellation as "the Chair of the Giant," or "the Throne of Jauzah." They also thought that the four brightest stars in the constellation represented four camels drinking from the River (Eridanus).

Hewitt tells us that, in early Egyptian astronomy, Lepus was "the Boat of Osiris," the great god of that country, identified with Orion.

The Hare is said to have been a creature which Orion specially enjoyed hunting and for this reason it was placed near him in the sky.

For the Naked Eye, Field Glass and Telescope

Gamma Leporis can be separated into a double star with a good binocular if it is held steadily.

"R" marks the location of Hind's "Crimson Star," a famous Variable of long period. Viewed in a telescope it resembles a drop of blood. At maximum it is of the sixth or seventh magnitude. At minimum it is eighth magnitude. Its period is 436 days. The spectrum of R Leporis indicates that "it is smothered with absorbing vapors, a sun near extinction, which at intervals experiences an accession of energy and bursts through its stifling envelope with explosive radiance, only to faint and sink once more."

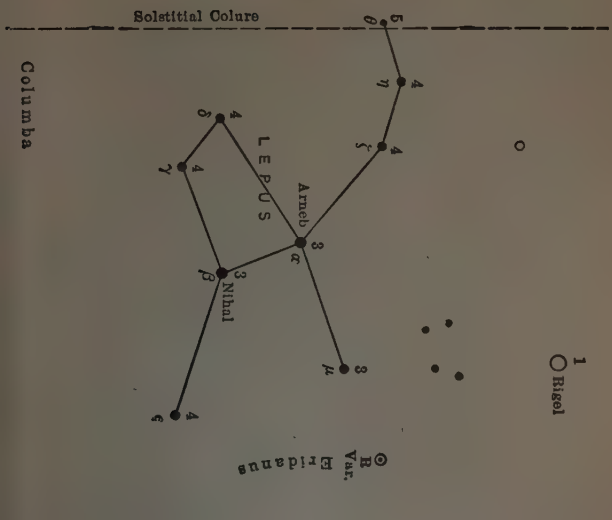
The following double stars are of interest for those possessing small telescopes.

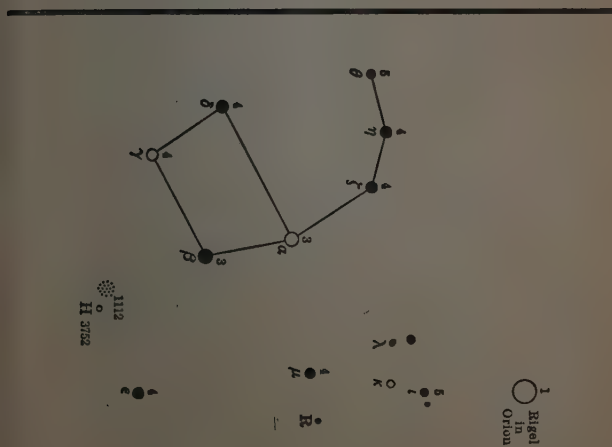
Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
α	2.6–9	36	156	Yellow–Gray. Difficult for 3 inch telescope.
γ	3.8–6.4	95	350	Yellow–Garnet. Field glass double.
κ	5–8	3	358	Yellow–Blue.
H 3752	6–9.5–9	3 59	104	A triple.

About 6 minutes east of α Leporis is H 3780, a multiple star. Magnitudes 7–8–9–8.5, a beautiful object for a small telescope.

Observe the cluster 1112, a splendid globular cluster discovered by Mechain, which Messier described as a starless nebula with a brilliant center. Herschel was the first to resolve the nebula into stars. Five stars out of the two hundred in this cluster are known to be Variable.

LEPUS


Solstitial Colure
Columba
LEPUS
Arneb
Nihal
Eridanus
R Var.
1 Rigel


1112
H 3752
1 Rigel in Orion

CANIS MAJOR

CANIS MAJOR (kā′-nis mā′-jor)—THE GREATER DOG
(Face South)

LOCATION.—The three so-called "Belt Stars" in Orion's girdle, point southeast to the bluish white star Sirius in Canis Major, known also as "the Dog Star." It is to us the most brilliant star in the heavens.

Sirius rises in the early evening about Christmas time, by March 1st it shines directly south, and it is lost to our view in the west by the middle of May.

The stars Betelgeuze in Orion, Procyon in Canis Minor, and Sirius form a nearly equilateral triangle. These stars, with Naos in the Ship Argo and Phaet in the Dove, form a huge figure known as the Egyptian "X."

Mythology

All others he excels; no fairer light
Ascends the skies, none set so clear and bright.

MANILIUS.

From the earliest times Sirius has been known as "the Dog of Orion," and the star has been famous since the dawn of history.

Sirius was worshipped by the Egyptians, and many of their temples were built in its honor, notably the temple of Isis at Denderah. The Egyptians held Sirius in high regard for the service the star rendered them, for its appearance in the east warned them of the rising of the River Nile each year, and enabled them to plan for the inundation.

Mythology—*Continued*

Sirius has always been known as "the Dog Star," a name that may have been given it for the reason that the star's appearance served as a warning, just as the barking of the dog warns his master of danger.

The term "Dog Days" is associated with Sirius. These days derive their name from the fact that in ancient times Sirius was overhead at this season of the year in the day time, and its rays were supposed to mingle with the sun's rays and thought to add to the heat it radiates, thus accounting for the unusual heat in Summer.

A legend that has come down to us concerning Sirius relates that it was the dog Aurora gave to Cephalos. It was said to have surpassed all other dogs in fleetness. Cephalos thought he would prove this fact to his satisfaction by racing his dog with a fox. For a time the two creatures were on even terms. Jupiter was so pleased with the performance of the dog that he placed him in the sky as a reward.

CANIS MAJOR

Sirius

Sirius has a magnitude of −1.58, and is 324 times brighter than the average sixth magnitude star. It is 27 times brighter than the sun, 2.5 times as heavy, nearly twice the diameter.

Of all the stars visible to the naked eye in this latitude, Sirius is the nearest, at a distance of 8.6 light years. At this distance the sun would appear as a star a little brighter than Polaris.

According to Professor Eddington: "Sirius has an inconceivably high velocity in space yet it has moved only the breadth of the Moon since Ptolemy's time. It has a surface temperature of 20,000° F. Were it as close to us as our sun, the earth would be consumed instantly.

Sirius has a proper motion, that is, a motion across the line of sight, of approximately 40,000 miles an hour.

Spectroscopically, Sirius represents a type of star less advanced in development than our sun, but older than the "Orion" stars.

Its radial velocity, that is, its rate of speed in line of sight, is 5 miles a second toward us.

Professor Russell gives its probable diameter as twice that of the sun.

The Companion to Sirius

Famous as the star Sirius is, it has a still more remarkable companion. In fact, the companion to Sirius may be regarded as one of the most wonderful and interesting stars in the Universe.

In 1834, variations in the motion of Sirius were detected, and Bessel announced in 1844 that his mathematical investigations led him to the conclusion that Sirius had a companion star revolving about it.

In 1862, Alvan Clark, of Cambridge, Mass., the famous maker of telescopic lenses, had just completed a new object glass of 18 inch aperture. Turning his new telescope on Sirius to test the objective, he observed at once a faint companion star, thus confirming visually Bessel's mathematical prediction.

The Companion to Sirius—*Continued*

Since its discovery this companion star has been under constant observation. Only one ten-thousandth as bright as Sirius, it revolves with this brilliant star around a common center of gravity, in a period of about fifty years, almost exactly the value predicted by Bessel.

The actual distance between Sirius and its companion averages almost exactly twenty times the distance that separates us from the sun (93 million miles). The orbit is highly eccentric, and the distance between the two stars varies considerably. In 1894 the companion star was so close to Sirius as to be invisible even in our largest telescopes.

During the interval that the companion has been under observation, it has made a little more than one revolution about Sirius.

The principal fact of interest concerning the companion to Sirius is the disproportionate relationship between its size and mass. In this respect the star presents an anomaly. A study of its mass has greatly modified our theories of the atom.

Eddington considers that the great density shows that the atoms have been practically stripped of their planetary electrons and can therefore be packed together more closely than matter under "normal" conditions.

The companion to Sirius is known as a "White Dwarf" star, and in point of age is one of the oldest stars. It has a mass .9 times that of the sun, yet it is 360 times fainter. It is ten thousand times fainter than Sirius.

In size it is about three times the diameter of the earth, and has 250,000 times the earth's mass. One cubic inch of it weighs a ton. It is 3000 times as dense as gold, 5000 times as dense as lead, and 60,000 times as heavy as water.

The following comparison, compiled by Dr. W. J. Luyten, is of great interest:

A cubic yard of star-mass similar to that of the star Betelgeuze in Orion weighs one thirtieth of an ounce.

(*Continued on page 324.*)

The Companion to Sirius—*Continued*

A cubic yard of air such as we breathe on earth weighs two pounds. A similar amount taken from the sun weighs about a ton. A cubic yard of material taken from the companion to Sirius weighs more than 40,000 tons.

If a man of average weight were transported to this wonderful star he would weigh 2600 tons.

The companion to Sirius is also famous for the measure of proof it accords Einstein's Theory of Relativity. According to this theory, light leaving the intense gravitational field of the Companion would be "slowed down," and the consequent shift of the spectrum lines would indicate a recessional velocity of considerable amount.

As Sirius and the Companion form a close binary system, the easily measured radial velocity of the bright star is a certain means of checking the actual motion of the Companion toward or away from the Earth.

The spectra of Sirius and the Companion were, after a year's effort, successfully obtained at Mt. Wilson by Prof. Adams, who overcame the great photographic difficulties presented by the high brilliancy of Sirius and the faintness of the Companion.

Careful comparison, measurement and computation showed a "large shift as predicted. Expressing the results in the usual unit of kilometers per second, the mean of his measurements came to 19, while the predicted shift was 20."

For the Naked Eye and Field Glass

The star cluster 1454 (M 41) can be seen with the naked eye. Observe it with an opera or field glass and look for a red star in its center.

Between δ and o' note a remarkable array of minute stars, also a very red star.

Below η there is a very fine group.

CANIS MAJOR

Orion
Saiph
κ
Monoceros
50 M.
4
θ
Solstitial
Colure
Lepus
1 Sirius
α
2
Murzim
β
Muliphen
γ
ν¹
41 M.
CANIS MAJOR
3
ο²
5
ο¹
2 Wesen
δ
4
2
ε Adara
3
Furud
ζ
2
Aludra
η
4
κ
4
λ
Columba

For the Telescope

The following double stars are in this region of the sky. The Chart indicates their location.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
μ	5.2–8.9	2	340	White–Blue.
ν^1	5.5–8	17	262	
ϵ	2–9	7	160	
H 39.45	7–8	28	67	

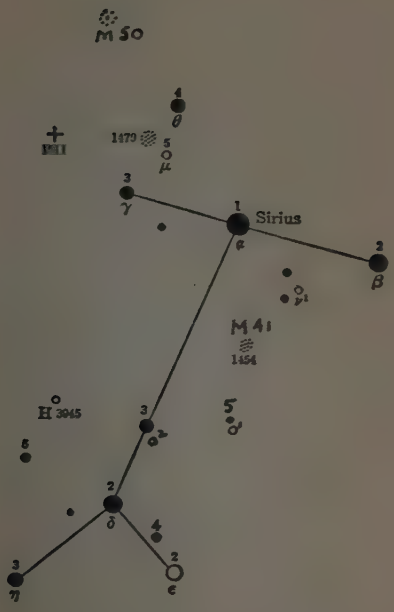
Note the nebula 1511 and the curving row of faint stars near it.

Also observe 1454 (M 41). It is a superb group in a 3-inch glass, and the red star near the center shows very clearly.

The sight of the brilliant Sirius in a telescope is entrancing, particularly when viewed as it is rising or setting. Bright rays of every hue dart from its flaming heart. As Tennyson expresses it:

> The fiery Sirius alters hue,
> And bickers into red and emerald.

CANIS MAJOR


M 50
4
θ
1479
5
μ
3
γ
1
Sirius
α
2
β
ν1
M 41
1454
H 3045
3
ω2
5
ω1
5
2
δ
4
3
η
2
ε

MONOCEROS

MONOCEROS (mō-nos′-e-ros)—THE UNICORN
(Face South)

LOCATION.—This inconspicuous constellation is situated east of Orion and lies between the constellations Canis Major and Canis Minor. Three of its stars of the fourth magnitude form a straight line running northeast and southwest, about nine degrees east of the bright red star Betelgeuze in Orion, and about the same distance south of gamma Geminorum.

Mythology

Monoceros is a comparatively new constellation, and hence there are no interesting legends connected with it. It is generally supposed to have been designed by the astronomer Bartsch, but Olbers and Ideler claim that it was invented as early as 1564. Scaliger is said to have found the figure on an ancient Persian sphere.

The Chinese asterism, "the Four Great Canals," occupied this region of the sky.

The Monoceros is said to be a species of unicorn. It is depicted in the old atlases as a creature resembling a horse with a long horn projecting from its forehead. It is claimed that, when pursued, the animal leaps from great heights, lands upon its horn, which breaks the fall and the animal is uninjured.

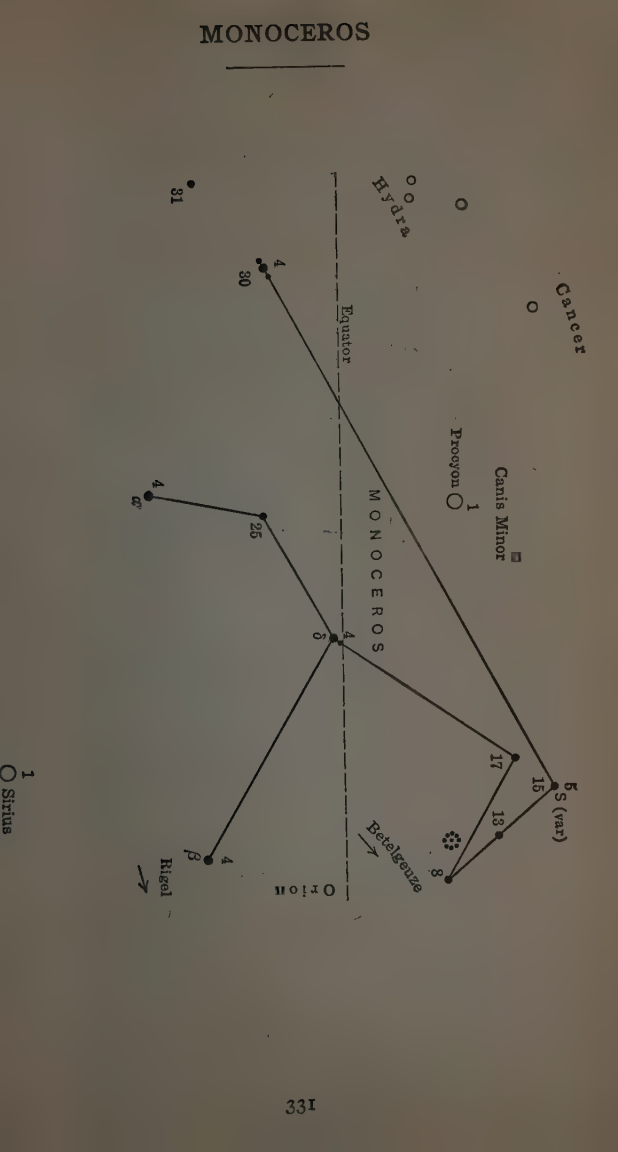
For the Naked Eye and Field Glass

A Nova or new star was discovered at Heidelberg, February 4, 1918, in this constellation about two degrees south and twenty minutes west of the fourth magnitude star 30 Monocerotis. When first observed it was 8.5 magnitude, and was recognized as a Nova by its spectrum. Examination of the Harvard Observatory plates showed that the Nova had been visible for fully a month before its discovery. It slowly waned to a faint star in the course of a few months.

Monoceros contains a remarkable object discovered by Professor Hubble. It is known as a "Variable Nebula." The nucleus of this nebula surrounds the irregular Variable Star R Monocerotis, which at maximum is 9.5 magnitude. The Variable is situated about midway between the fifth magnitude stars 13 and 15 Monocerotis. Unfortunately the details of this nebula are not visible in a small telescope. Long photographic exposures reveal the remarkable light changes in the nebula. These fluctuations are extremely rapid, being often perceptible in a single day's interval. The cause of the phenomenon is not known, but may probably be largely dependent upon the star it envelops.

See, For the Telescope.

MONOCEROS



Hydra
Cancer
Equator
Procyon
Canis Minor
MONOCEROS
Betelgeuze
Orion
Rigel
S (var)
Sirius

For the Telescope

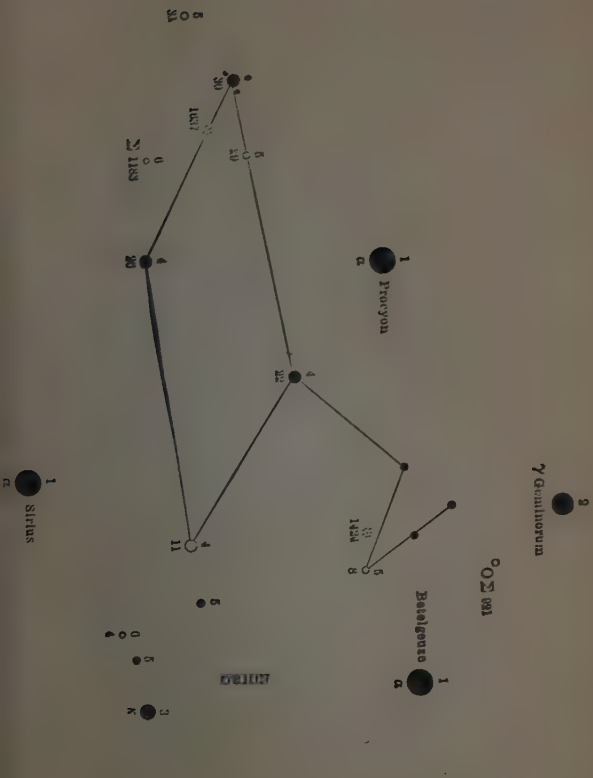
Webb thus describes Monoceros: "Rich in groups and clusters." The following double stars are listed.

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
11	4.7–5.2–5.6	7	132	A beautiful object.
		3	108	Triple
4	6–10–11	3	180	
		10	246	Triple. Difficult for 3" glass.
8	4–6.7	14	26	Gold + Blue
Σ 921	6–8.2	16	4	
Σ 1183	5.5–8	31	326	
29	6–11.7	31	104	Difficult for 3" glass.

Note the cluster 1424, visible to the naked eye, and a fine sight in a field glass. Also cluster 1637, fairly large and rich with stars of the ninth magnitude, including a fine double.

There is a glorious low power field about the star 8 Monocerotis. The star 15 Monocerotis is a short period Variable star; see chart p. 331.

MONOCEROS



ERIDANUS

ERIDANUS (ē-rid′-a-nus)—OR THE RIVER PO
(Face Southwest)

LOCATION.—Three degrees north, and two degrees west of the brilliant star Rigel, in the constellation Orion, lies the star β Eridani, the source of this great starry river in the sky. Thence it flows west till it reaches π Ceti, then drops south five degrees, and thence east southeast, its total length being 130 degrees.

The great curve the River takes, just east of Cetus, resembles a starry horseshoe.

Mythology

The scorched waters of Eridanus' tear-swollen flood
Welling beneath the left foot of Orion.

ARATOS.

Virgil called this starry River "the King of Rivers." It has also borne the following titles: "the River Euphrates," "the River Nile," "the River Jordan," and "the River Po."

The familiar legend relating to the constellation is as follows:

Phaëthon, the son of Phœbus and Clymene, desired to guide the chariot of the sun for one day. His father was loathe to grant his request, realizing the danger, but finally gave his consent, and carefully instructed his son how to drive the fiery steeds.

Phaëthon started on his wild career, but was unable to restrain the horses of the sun; they bolted, and there was danger of a great calamity. Jupiter sensed the danger to the world, and shot a thunderbolt, which, striking Phaëthon, hurled him into the River Po. His body was recovered, and buried by the nymphs beside the river. Phaëthon's sisters were grief-stricken, and spent their days weeping at his grave. Jupiter in pity changed them into poplar trees that they might be near and always protect their brother.

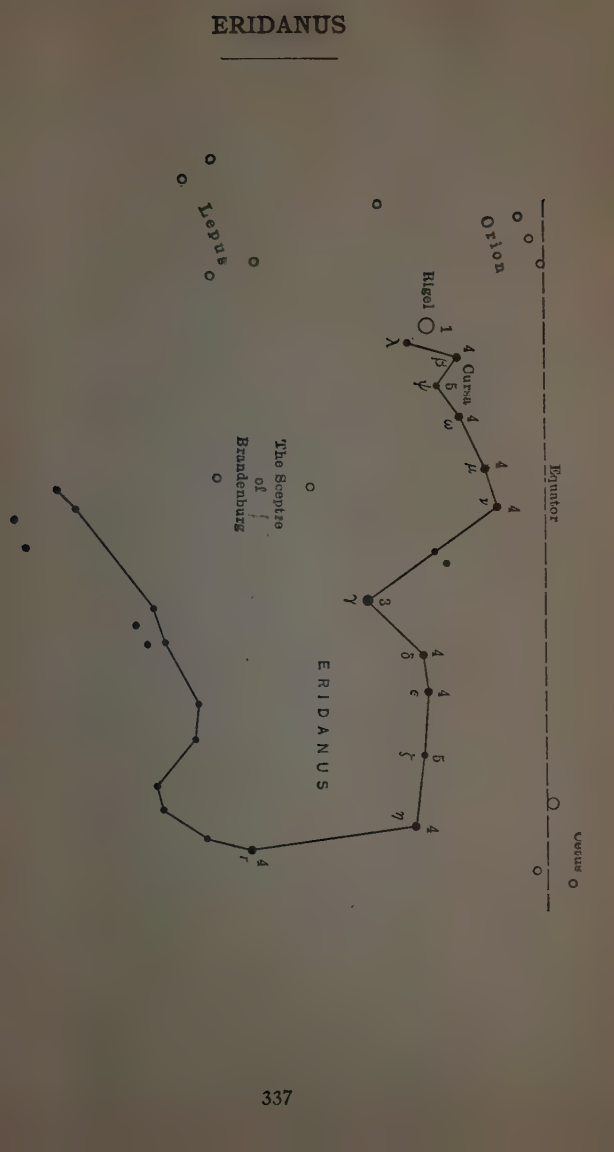
For the Naked Eye and Field Glass

Observe with an opera or field glass the attractive star group around β Eridani, and a pair of stars of orange hue below ν.

Acherna, alpha Eridani, the first magnitude star in the constellation, is too far south to be seen in this latitude. This star is 64 light years distant, but there are several stars in the constellation that are comparatively near us, ϵ Eridani is at a distance of 10.5 light years, omicron Eridani 15.5 light years, the latter being a triple star, all three moving together. The two which are nearest to each other are of interest, for we have been able to determine their mass. The two stars are .7 as massive as the sun, and give out .8 as much light.

The location of the obsolete asterism known as "the Brandenburg Scepter" is noted on the diagram.

ERIDANUS


Equator
Orion
Rigel
Cursa
ERIDANUS
The Sceptre of Brandenburg
Lepus

For the Telescope

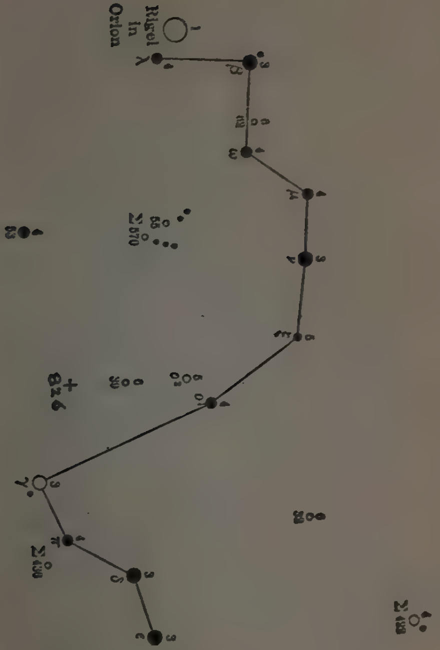
A partial list of the double stars in this constellation follows:

Double Star	*Magnitude*	*Distance, Seconds*	*Angle, Degrees*	*Remarks*
32	5–7	6	345	Topaz-Bluish. Fine contrast.
62	6–8	63	73	
Σ 122	6–8	6	232	Gold-Blue.
39	6–9	6	153	
55	6.2–6.7	9	318	Yellow-White.
Σ 570	7–8	12	258	
Σ 436	7–8	30	232	
γ	2.5–10	51	238	
o^2	4–9.1	85	107	

Note the planetary nebula 826. Lalande described it as the most extraordinary object of the kind he had ever seen.

The doubles 32 and o^2 cited above were discovered by Herschel in 1781 and 1783, respectively.

ERIDANUS



Note

A description of the Earth properly belongs in the following section on the Solar System, but it has been thought best to restrict this book to "the skies," particularly as lack of space forbids discussion of time, the calendar, etc. For an excellent presentation of this material the reader is referred to "Astronomy in a Nutshell" by Serviss in which some sixty pages are devoted to the Earth.

THE SOLAR SYSTEM

THE SOLAR SYSTEM

The Solar System has been introduced to the reader in the chapter for the beginner. It is now time to take it up in detail.

In the center of this great system, spins the Sun, a huge globular mass of flaming gases, inconceivably hot, giving forth practically all the light and heat for its whole family.

Around itself, the Sun, by the mighty power of gravitation, swings, in the order named, the following eight bodies called planets: Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, which all revolve in slightly elliptical orbits. The orbits of the planets lie approximately in the same plane (the plane of the ecliptic, as it is named), so that the shape of the Solar System as a whole is that of a great flat disk. These planets all shine only by reflecting a portion of the Sun's light. They have no light of their own. Their brilliancy is of wide range. This is mainly because of the difference in their distances from us, but is also due, in part to the difference in their sizes and reflective power (*albedo*), as well as to their position in relation to the Sun and the Earth. Because of distance, Uranus is but barely visible to the naked eye, and Neptune is never seen without a telescope; while Mercury is so close

to the Sun that it appears but at certain intervals, and then, under perfect conditions only, is visible without a glass. Four of the planets, however, Venus, Mars, Jupiter, and Saturn, are those "stars" which shine to the naked eye clear and bright, without the "twinkle" of the real stars, and, as said before, two of them, Venus and Jupiter, are those which so often sparkle in our early evening and morning skies with such luster and brilliancy.

The inner four of the eight planets are comparatively small and dense, or heavy, and the outer four are large and light.

The periods of their revolutions about the Sun—their "years,"—vary with their distances from it, between 88 days and 164 years. This is in obedience to a definite law of motion which insists upon an exact relation between such times and distances.

The orbits of the planets in regard to the Sun are ellipses, it is true, but in relation to space they are, because of the motion of the Sun along its celestial path, vast spirals; so that, far from returning to the same spot in the Universe at the completion of one revolution about the Sun, a planet never passes over the same place twice.

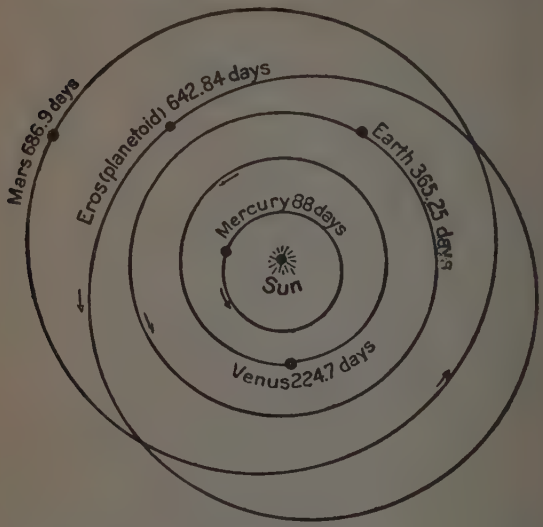
Refer to the diagram on p. 159.

Around most of these planets, revolve from one to ten smaller bodies, called moons or satellites. These satellites, of which our Moon is one, shine also only by reflected light.

The Sun, planets, and satellites all rotate upon their axes, in periods ranging from a few hours to several months.

Between the orbits of Mars and Jupiter is a large number of still smaller bodies, called asteroids or planetoids. Of these, over 1000 have been discovered, sweeping, each in its own orbit, as part of a great ring around the Sun.

Unique among the solar family are the "fiery-

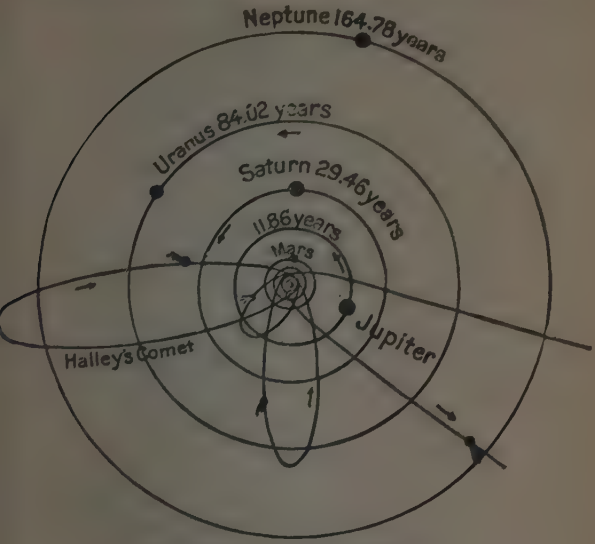


The Orbits of the Terrestrial Planets and One of the Planetoids
(Drawn approximately to scale)

haired" comets, those ancient portents of evil, which swing in narrow ellipses of great variety, some contentedly remaining within the planetary boundaries, and others rushing far into the emptiness beyond to return again to view only after hundreds and even thousands of years. Indeed, some astronomers believe that a per-

centage of the comets are truly wanderers in space, which bow to the Sun but once, and pass on never to return.

Least in size, but by far the most numerous, are the meteors, chips, so-to-speak, from worlds in the making, some of which are herded together



The Orbits of the Major Planets
(Drawn approximately to scale)

in vast swarms, while others pursue more lonely paths. But all, alike, obey the great law, and revolve in stated orbits around the Sun, until they collide with one of the planets, or, disturbed by a too close approach to such a large body, are swung into a new path that ends in the Sun itself. It is the fiery dissipation of a meteor, heated

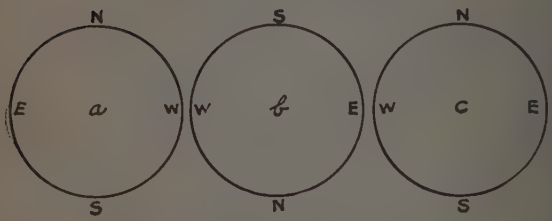
to a great temperature by the friction of our atmosphere, which causes the phenomenon of a "shooting-star."

It is probable, also, that a "cloud" of almost dust-like particles of matter extends through much of the Solar System, particles too small to be of appreciable size or weight.

A full table of the Elements of the Solar System is given in the appendix.

All the members of the solar family will be taken up chapter by chapter, and it seems fitting to begin with the Sun itself.

Orientation of Sun's Image



A. Direct view with naked eye.
B. As viewed in astronomical telescope.
C. Projection on a screen.

THE SUN

Of all the heavenly bodies the sun is of the greatest practical importance to mankind. It is responsible for our existence, and our well being is absolutely dependent on it.

Without the stimulation of the sun's heat there could be no vegetation, without which life on the earth would be unsupportable.

The Sun is the nearest star, hence it is of prime importance that we should endeavor to ascertain everything we can about it. To quote from Sir William Herschel: The influence of this eminent body on the globe we inhabit is so great and so widely diffused, that it becomes almost a duty to study the operations which are carried on upon the solar surface.

Thanks to the assiduous efforts of astronomers over a long period of years and various ingenious devices invented by them for developing research work, many facts of vital interest have been ascertained relating to the sun.

The possessor of a three-inch telescope may derive much pleasure and profit by observing the sun, but great care must be used or the sight will be permanently impaired. Many telescopes are equipped with shade glasses of neutral tints, which, when screwed to the eyepiece, admit of direct solar vision. If this method is used, the

aperture of the objective should be decreased by means of a diaphragm placed over the objective, otherwise the heat is liable to crack the solar eyepiece, thus endangering the eyesight.

A smoked glass may also be used in place of a solar eyepiece, and answers very well if it is well covered, but it is a dangerous method to employ, and rather than take the risk, the method of viewing the sun by projecting its image on a screen should be adopted. This, in addition to being perfectly safe, permits a number of persons to view the solar phenomena at the same time. It is best to fasten the screen to the telescope by a light framework, over which a black cloth should be stretched to keep out the light, and render the image more distinct. As a further screen, the object glass should be allowed to project through a piece of cardboard.

It is unnecessary and dangerous to locate the sun by sweeping for it, as, by experimenting a little, the sunlight can be made to appear on a paper held close to the eyepiece.

The most satisfactory views of the sun are to be had through a solar eyepiece, which, by means of a prism, diverts most of the sunlight, and permits of a direct view of the solar phenomena without running any danger of ruining the eyesight. Even with this device *a shade glass must be used.*

The phenomenon of especial interest to the observer with a small telescope who directs his attention to the sun, are the sun spots.

Sun spots are now known to be cyclonic disturbances of vast extent and terrific violence on

the surface of the sun. The umbra of a spot, that is the dark central portion, is a powerful magnetic field, a maelstrom of swirling "flames" of elemental gases. The umbra is not nearly as hot as the rest of the sun's surface.

The spots appear dark only in contrast to the rest of the solar surface. In reality they are hotter and more brilliant than molten steel.

Sun spots range in size from five hundred to one hundred and fifty thousand miles in extent, and large ones can be seen with the naked eye, using a smoked glass, or an over-exposed photographic film to protect the eye.

The spots often change in size from day to day. Some seem to disintegrate and disappear in a few days, while others remain intact and persist for several successive periods of the sun's rotation. It is good practice to make a sketch of the spots as they are observed, in order to note changes in their appearance from day to day.

On the average the spots travel across the sun's disk in a little over fourteen days.

There is a great variation in the number of spots visible in different years. In 1843 Schwabe, of Dessau, after collecting data relating to sun spots observed over a period of forty years, announced the discovery that this data proved that there was a wax and wane in the number of spots visible yearly, and a period of eleven years was indicated. The last maximum was in 1928.

In 1917, the previous year of sun spot maximum, there were spots on the sun every day. In 1913, the sun was spotless 312 out of the 365

days. The cause of the periodicity of sun spots is not known.

There is a direct connection between sun spots and terrestrial magnetic storms, and displays of the Aurora Borealis. When a sun spot is central on the sun the earth is bombarded by electrons freed from the atoms by the disturbance and hurled forth by the radiant energy of the sun. These electrons excite the earth's atmosphere and cause the beautiful displays of the Northern Lights.

Attempts are now being made to establish a relationship between sun spots and the factors pertaining to meteorology.

Excellent views of sun spots may be had through the solar eyepiece, by inserting between the lenses of the eyepiece used in connection with it, a piece of cardboard, which has a hole pierced through its center with a red-hot needle. This method reveals much detail in the spots.

Eclipses are, of course, of the greatest interest, especially total eclipses. They are described and explained in the special chapter devoted to them.

The so-called solar prominences are the most spectacular of all solar phenomena. They are geyser-like flames of hydrogen and helium gas that burst forth from the sun's surface, sometimes rising to a height of 500,000 miles. A rise of 120,000 miles in twenty minutes has been observed. The prominences can only be seen when on the sun's limb, and then only through the slit of a spectroscope, except at times of total eclipse. It is hardly worth while to attach a spectroscope to a telescope of less than five-inch

aperture. For those who have suitable instruments, spectroscopic observations offer a rich field of interest and study.

In closing this brief reference to the sun the writer emphasizes again the danger of observing the sun directly without interposing a shade glass.

FACTS CONCERNING THE SUN

Magnitude	*Distance from Earth*	*Diameter*	*Rotation Period*	*Temperature*	*Rate of Speed through Space*
—26	92,870,000 miles	864,000 miles	27 days	10,000° F.	12 miles a second

ON THE SCALE EARTH EQUALS 1

Diameter	*Mass*	*Density*	*Surface*	*Volume*	*Surface Gravity*
109	333,434	0.26	11,900	1,300,000	28.

The Sun's light is 600,000 times that of the Moon. Of the total light and heat in the Sun the Earth only receives $\frac{1}{2,200,000,000}$th part.

The following illustrations will give the reader some idea of the Sun's size, temperature, and distance from us:

A railway journey around the Earth at 35 miles an hour would take thirty days. It would take at that rate eight and one half years to circle the Sun.

One hundred and nine globes the size of the Earth, placed edge to edge, would extend from one limb of the Sun to the other if it were a flat surface.

"If a bridge of ice 2.1 miles wide linked the Sun to the Earth, and the Sun's radiant heat were concentrated on it, the bridge would be melted in one second."

If your arm was long enough to reach from the Earth to the Sun, you would not live long enough to realize that you had touched a hot substance. It would take 100 years for the nerves to translate the sensation to the brain.

Every 16 square feet of the Earth's surface receive 1 horse power of solar energy. Every square foot of the surface of the Sun emits 8200 horse power of energy.

Tyndal has expressed the following interesting thought: Without solar fire we could have no atmospheric vapor, without vapor no clouds, without clouds no snow, without snow no glaciers. The ice of the Alps has its origin in the heat of the Sun.

Eddington estimates the *internal* heat of the Sun at about 40 million degrees; it seems that this is probably the internal temperature of most of the stars. "Do not imagine that 40,000,000 degrees is a degree of heat so extreme that temperature has become meaningless. These stellar temperatures are to be taken quite literally. . . . I suppose that nine-tenths of the matter of the Universe is above 1,000,000 degrees."

THE MOON

The mean distance of the moon from the earth is 238,818 miles. Its diameter is 2170 miles, and it is a little larger than the continent of South America. Because of the moon's comparative proximity to the earth, it is the easiest and, at first, the most interesting of telescopic objects to the owner of a small telescope.

A telescope which magnifies only one hundred times will show a spot on the moon's surface whose diameter is 1223 yards. One which magnifies a thousand times will enable us to perceive objects on her surface whose dimensions are only 122 yards, which does not much exceed the size of the Capitol at Washington. The highest power yet applied to the moon, a power of six thousand, brings our satellite to an apparent distance of forty miles.

No object that could with the slightest appearance of probability be ascribed to the labors of intelligent creatures has ever been detected on the moon's surface.

We know more of the physical formation of the face of the moon turned toward us, than we know of many parts of Asia, South America, and the interior of Africa.

More than five hundred features of the lunar surface have received names.

Water cannot possibly exist as a liquid on the moon, for the temperature of the moon's surface during the long lunar night is probably not far from 200° below the zero mark on a Fahrenheit thermometer. During the day the temperature rises to a probable maximum of about 200° F.

The light of the full moon, which equals the light of 100,000 stars of zero magnitude, is one-600,000th part of the sun's light, and about twelve times the light of the half moon. The moon reflects about one-tenth of the light which falls on it from the sun. In the whole heavens the stars give about one-eightieth as much light as the full moon. The earth reflects to the moon about fourteen times as much light as the moon sends to the earth. (See page 374.)

It is best to observe the moon with a low power, and under the varying conditions of sunrise and sunset, "which, like the corresponding times of the earth, abound with grand and beautiful effects of light and shade."

The best view of an object on the moon's surface is to be had when it is on the terminator, as the boundary line between the illuminated and the unilluminated portions of the moon is called. Those objects which are on the terminator early during the first quarter, will be found there early on the third quarter.

Although the general statement is true that we see only half of the moon, to speak more correctly we see about fifty-nine per cent of the moon's surface, although we never see this amount at any one time. This fact is due to

THE MOON, AT NINE AND THREE-QUARTER DAYS

Image inverted, as in astronomical telescope

Note the faint streaks radiating from Tycho, the almost circular crater in the upper part of the picture. The dark crater near the bottom of the photograph is Plato, where color-changes have been observed on the Moon's surface

From a photograph taken at the Yerkes Observatory

the "balancings" or *libration* of the moon, as it is called. The student is advised to consult text astronomy for a further discussion of this subject, as the treatment of technical matters does not come within the scope of this book.

Because of the phenomena of libration, it is impossible to give a fixed position to the various formations on the moon's surface with respect to the moon's "age," so that no precise instructions can be given where to look for them.

The nomenclature of the moon is interesting because it serves to immortalize the names of many of the wise men of old whose memory might otherwise sink into oblivion. The astronomer Riccioli of Bologna, who published a chart of the moon in 1650, is responsible for most of the names of the interesting features of the moon's surface, and many of them are fanciful beyond reason.

The fact that seems to impress most persons who view the moon for the first time through a telescope is the rapidity with which it passes out of the field of vision. The high magnification emphasizes the earth's motion to such an extent and the speed with which we are travelling is thus made manifest in such a startling way, that few gaze without expressing their astonishment. Then, too, the detail brought out by even a low power is a matter of wonder. It seems almost incredible that in a small telescope craters on the moon only six miles in diameter can be seen distinctly.

The word crater is used in connection with the great ringed depressions, surrounded by moun-

tains, that are so numerous on the moon's surface. It is a misnomer as applied to these formations which are totally unlike terrestrial craters. Probably, they are of volcanic origin, but here the analogy ceases. Nothing on the earth is like them. Ringed plains is perhaps the best name for them, as it is descriptive in a measure. They are like great amphitheatres, sometimes 100 miles in diameter, surrounded by gigantic mountain walls that rise almost abruptly thousands of feet high. They often contain central mountains, or bowl-like pits.

The lunar landscape is all on a stupendous scale. It is said that there are twenty-eight peaks on the moon that exceed in height our most lofty mountains. Everywhere on the moon's surface are traces of cataclysmic action that is almost beyond our comprehension.

The Moon is mainly responsible for the action of the tides.

Because of its small size the gravitational pull of the moon is only $\frac{1}{6}$ that of the earth, consequently upheavals on the moon transcend in violence those on the earth:

It would be easy for a man transported to the moon to jump over a barn.

A three-inch field gun would have a range of 280 miles.

Babe Ruth's home run hit would go a mile beyond the ball grounds and Bobby Jones' drive would carry 6 miles.

The Diagrams of the Moon

These are sketches from a series of fine photographs that were published in Mr. Garrett P. Serviss's excellent book entitled *The Moon.* They are intended only to guide the student in the identification of the lunar wonders visible in a three-inch telescope, and make no claim to exactness or pictorial resemblance.

Only a portion of what appears on the earlier diagrams is repeated in the successive views, as their repetition would tend to fill up the diagram with names, leading to confusion. In each diagram therefore, particular stress is laid on the additional features of the moon's surface that the ever-advancing sunlight reveals.

In conclusion, the diagrams of the moon represent its telescopic or inverted appearance, so that the north point is at the bottom, the south at the top, the east to the right, the west to the left side of the diagrams respectively.

MOON—PLATE I

The narrow crescent of the moon illumined by the sun, as shown in the opposite plate, presents few objects of interest to the observer, but as each successive night of observation until the moon is full presents new material worthy of attention, it is well for the student to master the details as they are presented.

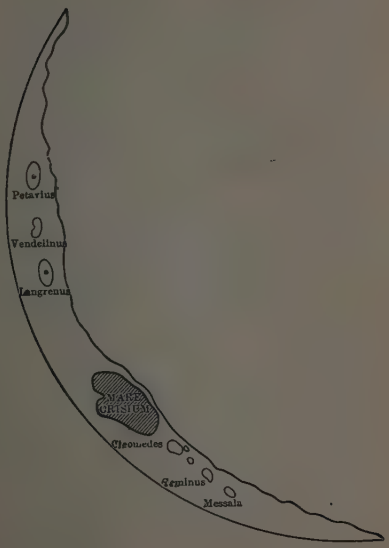
The Mare Crisium, or the Sea of Crises or Conflicts, as it is called, is the most prominent object visible at this time, and because of its dark hue the analogy to a sea is striking. It measures 350 miles from north to south, 280 miles from east to west. Note Cape Agarum, 11,000 feet high, jutting out into the sea on the southwest, and two small craters on the surface of the sea's floor a little east of its center. The southern one is named Picard, the northern Pierce.

North of the Mare Crisium is the crater Cleomedes. It is 80 miles in diameter. One peak on its wall is 10,000 feet high and it contains a central mountain divided by three clefts. On its eastern wall is a very deep crater named Tralles.

If the atmospheric conditions are favorable, a certain amount of detail can be seen on the dark or earthlit portion of the moon. The brilliant crater Aristarchus, and the darkest crater, Grimaldi, on the eastern limb of the moon, have been seen.

PLATE I

Moon's Age 3.85 Days



MOON—PLATE II

Petavius is one of the finest objects on the moon. It measures 100 miles from north to south. Its wall is divided by many valleys, while in the center of its vast plain rises a mountain 5000 feet high. A straight line radiates from this mountain, extending southeast to the wall of the crater. This line, which in reality is a great cleft, one of many on the moon's surface, can be easily seen in a three-inch glass. The best time to view it is a day or so after the full moon, when the sun is setting on the western limb of the moon. In formation these clefts or rills, as they are called, are analogous to our western canyons. Petavius is especially noteworthy because of the convexity of its floor, the center of which is 800 feet higher than its edges.

Langrenus is 80 miles in diameter. It contains a mountain peak 5800 feet high. Note three small craters just northeast of Langrenus forming a triangle.

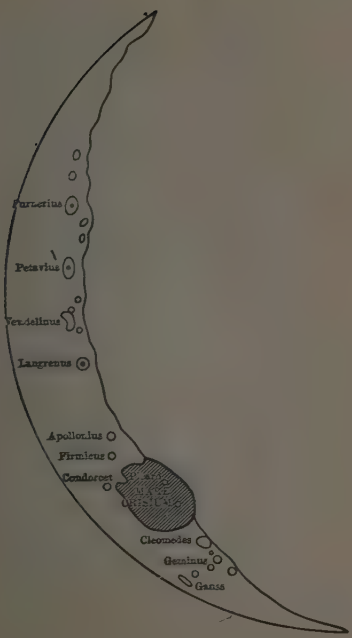
Vendelinus is pear-shaped, and therefore easily identified. Note a small but brilliant crater on the northeastern slope of Furnerius.

Burckhardt is the name of the crater just north of Cleomedes. North of it is Geminus, 54 miles in diameter. Its western wall rises to a height of 16,700 feet.

Gauss, from north to south, measures 110 miles.

PLATE II

Moon's Age 3.87 Days



MOON—PLATE III

The diamond-shaped Sea of Fecundity and the Sea of Nectar, pentagonal in form, are now visible. At the south of the latter sea, note Frascatorius with its north wall broken down. Endymion near the western limb is elliptical in appearance. Its west wall in places is 15,000 ft. high. View Endymion 3 d. 7 h. after the new, and 2 d. 9 h. after the full moon.

N. W. of Fabricius and Metius is a deep cleft. On the tip of the southern horn of the moon the peaks of the Leibnitz Mts. may be seen.

Messier, 9 m. across, and Messier A are noteworthy. Two slightly diverging streaks run east from the latter for a long distance. They seem artificial, but their character is still an enigma.

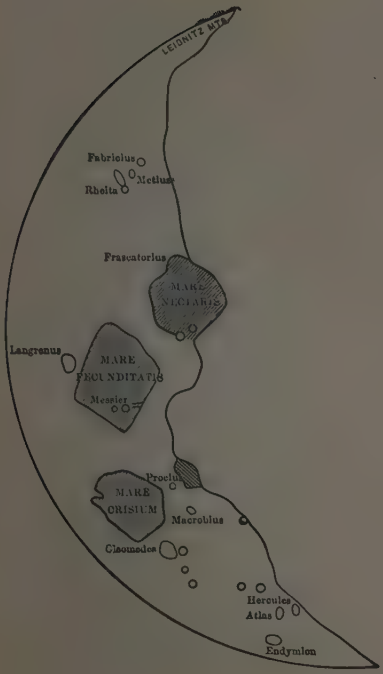
Alleged changes have taken place in the shape of these craters.

East of Proclus is a peculiar yellowish-brown patch somewhat diamond-shaped. It is called Palus Somnii, or "Marsh of a Dream."

Hercules and Atlas are best viewed 5 or 6 days after the new moon, or 3½ days after the full moon. The former contains a crater pit, and is 46 m. across. In the center of Atlas, which is 55 m. in diameter, rises a mountain.

PLATE III

Moon's Age 5.54 Days



MOON—PLATE IV

Note the crooked line of the Altai Mts. and the Taurus and Hæmus ranges, with Pliny 32 m. across, between them. Dawes lies just west of Pliny.

East of the Sea of Nectar is a striking group, Theophilus, Cyrillus, and Catharina. The former is 64 m. across. Its wall in places is 18,000 ft. high. Its central peak can be seen beyond the terminator 5 d. after the new moon. Cyrillus is trapezoidal in form and contains two peaks. The N. W. portion of its wall has been demolished to make way for the wall of Theophilus.

Posidonius on the western shore of the Sea of Serenity is 62 m. across and contains a crater. Its interior plain lies about 2000 ft. below the outer surface of the moon. It is best viewed 6 d. after the new moon. North of it is a "V" shaped bay called the Lacus Somniorum or "Lake of Sleepers." A peculiar ridge winds its way from Posidonius to Pliny across the Sea of Serenity. South of Posidonius is Le Monnier with its eastern wall broken down.

Mt. Argæus, N. W. of Pliny, 8400 ft. high, is a fine sight when the moon is 5 d. old.

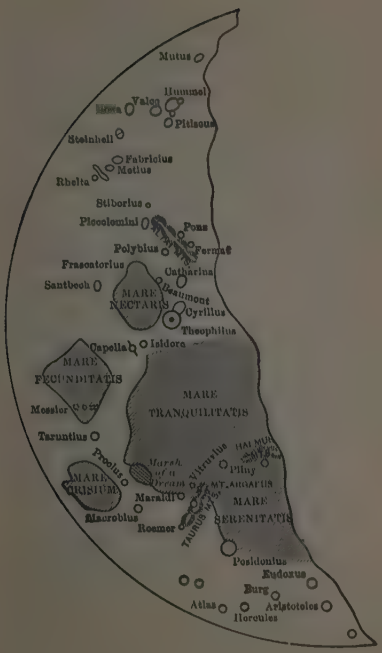
North of the Sea of Nectar note Isidore and Capella with a peak over 13,000 ft. high between them. The ring of Capella is cut down by a broad cleft.

N. E. of the Mare Crisium note Vitruvius, Maraldi, Littrow and Rœmer.

South of Fabricius and Metius are three small craters close together, Pitiscus, Hommel, and Valcq. Steinheil, N. W. of them, is shaped like the figure "8." Polybius and Pons lie on opposite sides of the Altai Mts.

PLATE IV

Moon's Age 5.74 Days



MOON—PLATE V

In the south Maurolycus, 150 m. across, and Stöfler are conspicuous. The former is best viewed about the time of the moon's first quarter. At full moon it is practically invisible. Some of its peaks are 15,000 ft. high.

About the center of the moon, just west of the terminator, lie Albategnius, 65 m. across, and north of it Hipparchus, 90 m. in diameter. The latter exhibits signs of demolition and is presumably older than Albategnius which is very deep and comparatively perfect.

Note Menelaus and Sulpicius Gallus on the south shore of the Sea of Serenity, with Manilius between them. It is not known why these and a few other craters are so conspicuously bright.

The Caucasus Mts. are prominent south of Eudoxus and Aristoteles (50 m. across). In the center of the range is Calippus.

The dotted line across the Sea of Serenity represents a light streak radiating from Tycho, 2000 m. to the southward. It crosses Bessel, 14 m. in diameter, situated in the midst of the Sea of Serenity. The character of the light streaks on the moon is unknown.

The small triangular shaped crater east of the Caucasus Mts. is Theætetus, interesting because a French observer claims to have seen smoke rising near it.

The Sea of Serenity is 430 m. long and about as wide. Its area is 125,000 sq. m.

Godin, 23 m., and Agrippa, 27 m. in diameter, respectively, are fine objects when seen on the terminator. A minute point of light is alleged to have been seen near them.

S. E. of Piccolomini are three craters forming a triangle. Zagut is the name of the largest.

PLATE V

Moon's Age 7.75 Days

MOON—PLATE VI

Clavius is conspicuous in the south. It is 140 m. across, 16,000 sq. m. in area, and a peak on its western wall is 17,300 ft. high. Within its walls 90 craters have been counted. If its surrounding wall were straight, it would cover the distance from New York to Buffalo.

Tycho, 54 m. in diameter, is the perfectly formed crater north of Clavius. A system of light streaks extending over a quarter of the visible hemisphere of the moon radiate from it.

North of Tycho, just west of the terminator, lie two groups containing three craters each. The largest in each group lies to the north.

The Apennine Mts., a grand range, start from Mt. Hadley, 15,000 ft. high, and terminate at Eratosthenes 450 m. to the S. E.

Eratosthenes, 38 m. across, is 8000 ft. deep. It contains three conspicuous central peaks.

Professor W. W. Pickering claims to have observed changes in the interior of the crater Eratosthenes, which he ascribes to organic life in the form of vegetation that flourishes while the sun shines and withers when night falls.

Archimedes, 50, Autolycus, 23, and Aristillus, 34 m. in diameter respectively, lie north of the Apennines. Cassini, to the north of them, contains two central pits. More than fifty objects have been detected within the walls of Archimedes.

Note the small peak Linné north of Mt. Hadley. Alleged changes have been noted in its form.

The Alps are pierced by a great cleft 80 m. long and from 3½ to 6½ m. in width. Its depth is at least 11,500 ft.

Ariadæus is connected with Hyginus by a valley best observed at first quarter. Hyginus is situated on the western shore of the Mare Vaporum or "Sea of Mists."

Note the Sinus Æstuum, or "Gulf of Heats," south of the Mare Vaporum.

PLATE VI

Moon's Age 9.22 Days

MOON—PLATE VII

Note Cichus, north of Tycho. A crater on its eastern wall only 6 m. across can be seen.

West of Birt note the Lunar Railway or Straight Wall, a cliff line 65 m. long and 1000 ft. high, best viewed one or two days after the first quarter. The western shore of the Mare Nubium, or "Sea of Clouds," outlines the profile of the "old lady in the moon." Her hooked nose is just S. E. of Ptolemy. Note Bulliadus 38 m. across, and 9000 ft. deep, and Gassendi, 55 m. in diameter. There are many curious clefts in the wall of Gassendi. North of it is Letronne, its north wall broken down.

Copernicus is conspicuous. It contains 8 central peaks, 3 of which are bright ones, and one is 2400 ft. high.

Plato, 60 m. across, is one of the darkest spots on the moon. Hevelius called it "the great black lake." South of it note Pico 8000 ft. high.

Capes Heraclides and La Place are at the eastern and western extremities respectively of the Sinus Iridum or "Bay of Rainbows." They are 135 m. apart. The former is 4000 ft. high, and its shadow forms the silhouette of the "moon maiden," best viewed when the moon is 11 days old.

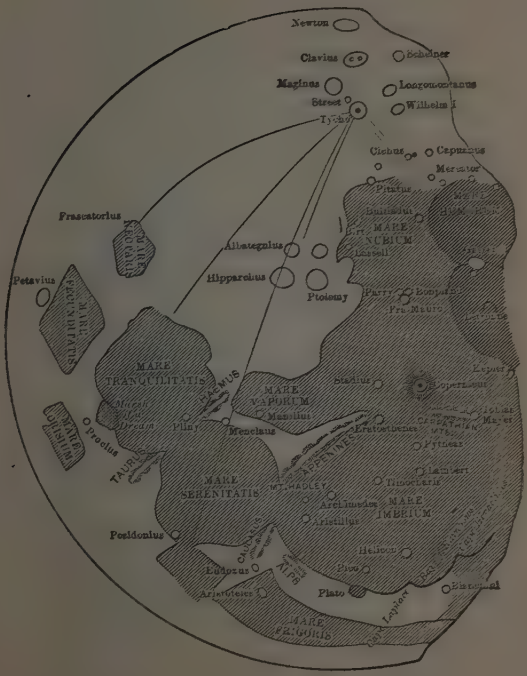
The Carpathian Mts. north of Copernicus are best viewed 10 days after the new moon. East of them is Tobias Mayer, 20 m. across and 9700 ft. deep. Kepler, 22 m. across, is notably bright.

Newton, south of Clavius, is 142 m. long and 24,000 ft. deep, the deepest crater on the moon.

Note the circular Mare Humorum or "Sea of Humors," the darkest of the seas.

PLATE VII

Moon's Age 11.78 Days



MOON—PLATE VIII

The telescopic view of the full moon, contrary to the popular notion, is disappointing. The brilliancy of the reflected light dazzles the eye, eliminates the shadows of the great peaks, and renders the interesting details invisible.

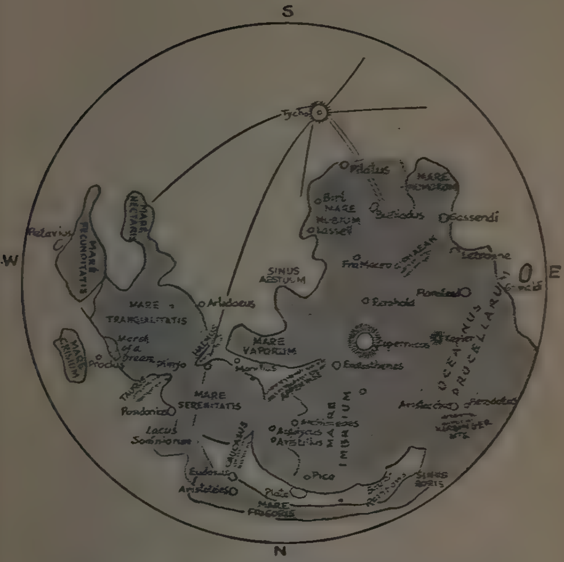
Grimaldi on the eastern limb, 148 m. long by 129 m. broad, is the darkest spot on the moon. N. W. of it in the Oceanus Procellarum or "Ocean of Tempests" is Aristarchus, the brightest spot on the moon. It is 28 m. across and connected with Herodotus by a short bright ray.

Herodotus is 24 m. across. A winding valley starts from it and can be traced across the sea for a distance of 100 m.

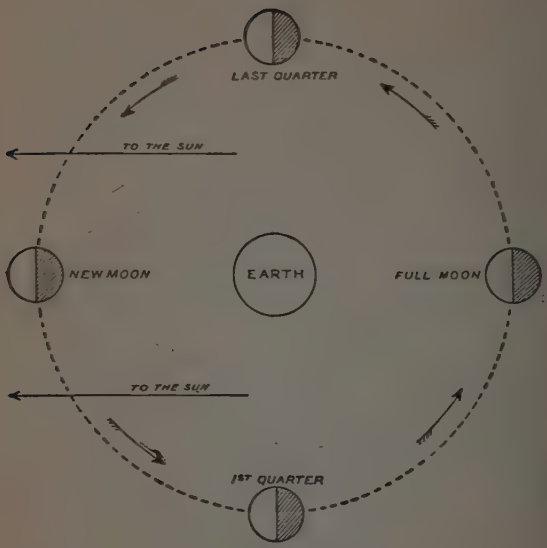
Note the dark patches west of Copernicus, the color of the Palus Somnii, the brilliant craters Proclus, Ariadæus, Menelaus, Manilius, Sulpicius Gallus, Pico, Aristarchus, and the black craters Plato and Grimaldi.

Observe the Riphæan Mts. north of the Mare Humorum, and the Harbinger Mts. north of Aristarchus. The dark patch north of the Mare Imbrium, extending from the Caucasus Mts. to the Oceanus Procellarum, is the Mare Frigoris, or "Sea of Cold." The bay that seems to connect the Mare Frigoris with the Oceanus Procellarum, north of the Bay of Rainbows, is the Sinus Roris, or "Gulf of Dews." Archimedes, Autolycus, and Aristillus are surrounded by an area of a lighter hue than that of the Mare Imbrium. This region is called "The Marsh of Corruption."

All the southern and western portions of the moon are wanting in detail, owing to the intensity of the light.



Drawn to a scale slightly smaller than that of the other diagrams.



The Phases of the Moon

Near the time of new moon, the whole disk is easily seen, the part upon which the Sun does not shine being illuminated by a pale somewhat reddish light. This is popularly known as the "old moon in the new moon's arms." This light is reflected light from the Earth, or Earth-shine. The Earth at this time, when viewed from the Moon, is nearly full. The ruddy color of the Earth-shine is caused by the light passing twice through our atmosphere. Leonardo da Vinci was the first man to explain this phenomenon satisfactorily.

LUNAR OCCULTATIONS

As the Moon moves eastward in the sky it frequently occults, or eclipses, a star and sometimes a planet. This is always an interesting sight to observe with a telescope, particularly if the star is a bright one.

A table containing the dates, time, and stars occulted, is published in the *Nautical Almanac*, which should be in the hands of all amateur astronomers. It can be obtained from the Superintendent of Documents, Washington, D. C. Price, $1.00. A time correction is necessary for those who do not live in Washington, D. C. The longitude of Washington is 5 hours, 8 minutes, and 15.7 seconds west of Greenwich.

The sudden eclipse of the star as the sharp limb of the Moon interposes is a startling phenomenon, and probably the most nearly instantaneous that the human eye beholds. This furnishes conclusive proof that there is practically no atmosphere on the Moon.

The most beautiful occultations are those when the star disappears behind the dark limb of the Moon, as between new Moon and first quarter.

Because of the Moon's eastward motion relatively to the stars, the disappearances, when viewed with the naked eye, will take place on the eastern or left hand limb of the Moon, the reappearances on the western or right hand limb. The reverse is true when the occultation is observed with a telescope.

THE PLANETS

While it is not within the scope of this work to discuss the planets in full detail, it has been thought best to give such facts and statistics concerning them as might prove of interest to the reader.

From the observational standpoint certain explanatory matter regarding them is necessary to prevent confusion, for it must be remembered that the constellations appear in different constellations at different times and are *not shown on the diagrams.*

In the four large plates that precede the seasons, it will be observed that a portion of an ellipse has been traced, and that this line has been designated the Ecliptic, which simply means the sun's apparent pathway across the sky. This is also the path of the planets.

This pathway is divided into twelve equal parts of thirty degrees each, and to these twelve divisions are given the names of the constellations of the Zodiac in the following order: Aries (♈), Taurus (♉), Gemini (♊), Cancer (♋), Leo (♌), Virgo (♍), Libra (♎), Scorpio (♏), Sagittarius (♐), Capricornus (♑), Aquarius (♒), Pisces (♓).

Confusion, therefore, respecting the planets can arise only in connection with a study of one

of the twelve constellations named above, so that whenever a star of any size not accounted for in the diagram, is seen in one of these constellations, the student may conclude that this is a planet; especially if the unknown star does not twinkle. Now, to identify the planet.

This can be done by referring to the diagram on page 491 or to a properly equipped planisphere, or an almanac, which states what planets are above the horizon, and which are morning and evening stars. By morning star is meant that the planet is west of the sun, and *rises before* the sun; by evening star, that it is east of the sun, and *sets after* the sun.

The Barrett-Serviss Planisphere is of great value in locating the heavenly bodies visible to the naked eye and should be in the hands of all amateur astronomers.

If the planet is in the west, and very brilliant, it is safe to assume that it is the planet Venus.

If it is brighter than any of the fixed stars, is some distance from the sun, and golden in light, it is doubtless the colossal Jupiter.

If it is noticeably reddish, it is probably Mars.

Saturn is distinguished because of its pale, steady, yellow light.

As for Mercury, Uranus, and Neptune, the former is very near the sun, and seldom seen; while Uranus and Neptune are so inconspicuous as to lead to no confusion on the part of the novice.

The following table of first-magnitude stars in the Zodiacal constellations confines the question

of identifying the planets to a comparison of the unknown star with the following-named stars:

Castor and Pollux	in Gemini.
Spica	" Virgo.
Regulus	" Leo.
Aldebaran	" Taurus.
Antares	" Scorpio.

The first four stars named above are white in color, so that either Mars or Saturn are readily distinguished from them.

As for Aldebaran and Antares, which are both red stars, not unlike Mars and Saturn in color and magnitude, the fact that the latter do not twinkle, and that they do not appear in the diagrams, should satisfy the observer of their identity. Reference to an almanac, or a few nights of observation, will in any case set at rest any doubt in the matter.

The Planets for the Telescope

In addition to the multitude of interesting objects scattered among the universe of stars, the planets of our own system offer much to be observed, and because their comparative proximity renders them more satisfactory objects to view in a small telescope, they may prove of greater interest to the beginning astronomer than those great suns that send us at best but faint messages of light, and concerning which our knowledge is secured mainly by the spectroscope.

The amateur astronomer with his three-inch glass has in the observation of the planets a

source of pleasure that can never wane. Their numerous changes in position add variety to the observations, and their near approaches to the earth lend the zest of anticipation to the interested student.

There is the greatest satisfaction in seeing with your own eyes the peculiar characteristics of the planets that our own sun illumines, of which volumes have been written and which the whole race of intelligent beings have wondered at. Much more can be seen with a small telescope than is imagined, and the sight of the satellites of Jupiter and the rings of Saturn is far more impressive and satisfactory than any amount of reading concerning them.

In the paragraphs *For the Telescope* referring to each planet there have been given only the details that can be seen with a small glass.

Taking up the planets in order, counting from the sun outward, the planet Mercury first claims our attention.

Mercury

Mercury is the nearest to the sun of any of the planets. On this account, and because of its rapid changes, it is seldom seen.

The most favorable time for observing it is just after sunset, or just before sunrise, during the months of March, April, August, and September, when it may be seen for a few successive days.

Mercury is also the smallest of the planets. Its diameter is about 3,000 miles; that of the Moon about 2,000.

Like the god it is named after, Mercury moves very swiftly in its orbit, at a speed varying from 23 to 36 miles a second, and completes its revolution about the Sun in 88 days.

Its distance from the Sun varies from 28.5 to 43.5 million miles.

It always turns the same face toward the Sun, as does our Moon toward the Earth.

The greatest distance it ever departs from the sun on either side varies approximately from sixteen to twenty-eight degrees. Its apparent motion resembles a pendulum, swinging from one side of the sun to the other.

So few have ever seen Mercury that even the very sight of that planet in an opera glass is a source of satisfaction. An opera glass, because of its large field, is most useful in looking for

Mercury—*Continued*

Mercury, although if its position is known it is easy to pick up in a telescope; use lowest power. In appearance it is brighter than a first magnitude star, and sometimes it seems of a reddish hue.

For the Telescope

The transits of Mercury across the sun's disk average thirteen in every hundred years, and are exceedingly interesting events to watch, even with a small telescope. The transits always occur in the months of May or November. November 8, 1927, was the date of the latest transit, and the next wholly visible in the United States will occur November 14, 1953.

Aside from the satisfaction of seeing Mercury, a pleasure that was denied to Copernicus even, there is little to interest the amateur telescopist save to note the phases that the planet assumes, which are similar to those of the moon. The crescent Mercury gleaming in the waning light of the dying day, and seen for the first time is a sight never to be forgotten.

Venus

Venus approaches nearer to the earth and is more brilliant than any other planet. It is bright enough to cast a shadow at night, and is sometimes visible even at noonday. It is almost as large as the earth, and oscillates, as Mercury does, to either side of the sun.

It never appears more than three hours after sunset, and as long before the sunrise, and is never more than forty-eight degrees from the sun.

Its distance from the Earth varies from between about 25 million miles when nearest to about 160 million when on the opposite side of the Sun. This causes an apparent variation in size.

Venus exhibits phases like the Moon, but is at its brightest to us when in the crescent phase, since it is then so much nearer than when it is "full."

Venus revolves about the Sun in 244.7 days.

Some astronomers, perhaps most, believe that, like Mercury, Venus always presents the same face to the Sun; others that it rotates in a time somewhat shorter than our day.

Venus has a dense atmosphere of very high reflective power, which makes the study of surface detail practically impossible.

Venus has no visible satellite.

Like Mercury, this planet also transits the disk of the Sun, but the occasions are rare, occurring about twice a century. The last one was in 1882; the next will be in 2004.

Venus—*Continued*

For the Telescope

Venus, so beautiful to the unaided eye, is also a telescopic disappointment, for aside from its phases, which are always a source of interest to observe, there are no surface features within the range of our optical power.

The planet is best viewed in the twilight or just before the dawn, when the faint light of day serves to deprive the radiant orb of a portion of its brilliancy. Seen under these conditions the crescent Venus is one of the most beautiful objects in the heavens. Of course if the telescope is equatorially mounted, both Venus and Mercury can be seen in broad daylight.

Showing the phases of Venus and the comparative apparent changes in size.

These phases were first observed by Galileo, in 1610. That the priority of his discovery might not be questioned, he announced in an anagram:

"Haec immatura a me jam frustra leguntur, o. y." which is bad Latin for, "These matters still immature, and as yet (studied) in vain, are read by me." Four months later, he published the key to the anagram:

"Cynthiæ figuras æmulatur Mater Amorum," which is, "(Venus) the Mother of the Loves imitates the (changing) figures of Cynthia (the Moon)."

Mars

Mars, the most talked of planet, is in physical condition more like the Earth than any of the others, although it is only about one-half the diameter of the Earth and about one-seventh of its volume. It has an atmosphere, though one less dense than ours; its seasonal changes are similar to ours, but about twice as long, and its surface, except for water areas like our oceans and seas of which it has none, seems fairly comparable to that of the Earth. Mars is more than half again as far from the Sun as is the Earth—141,500,000 miles. It rotates in about 24½ hours and revolves about the Sun in 686.9 days. The relation between the Martian year and ours is such that the Earth passes between the Sun and the planet only once every two years. It is at these times that the planet is nearest to us, and once every fifteen years, when Mars is closest to the Sun, these approaches lessen the distance between us to about 35 million miles.

Mars has two moons (Deimos and Phobos) which were discovered in 1877. They are both very small bodies, the largest estimates of their sizes being 35 and 10 miles respectively. The motion of the inner satellite is unique. It revolves about the planet in about 7½ hours.

Mars—*Continued*

Viewed from Mars it would rise in the West and set in the East *three times a day!* It is the only satellite that revolves faster than its primary rotates.

It is interesting to note that Swift, in *Gulliver's Travels*, described Mars with two small moons; he even closely approximated their strange periods, much to the amusement of astronomers for years, until the discovery of the actual satellites left the scientific world amazed at the accuracy of these wild guesses.

The much discussed question of life on Mars cannot be taken up here more than to say that modern research offers no proof that there is not, nor any reason why there should not be life of some sort upon the surface of this smaller but "older" brother of the Earth. It has an atmosphere which contains the water vapor indispensable to life as we know it, and its temperature, while lower than the Earth's, is not too cold. It may be said in passing that the "canals" have never been considered canals even by the most noted of the observers of Mars, Dr. Percival Lowell, who believed these lines seen upon the surface of the planet to be bands of vegetation, many miles wide, flanking the conduits of a great irrigation system which bring to the arid plains of the planet the water from the polar caps melting in the summer sun.

To give an idea of the difficulty of ascertaining observational facts respecting the planet, it may be noted that we can see with the naked eye

Mars—*Continued*

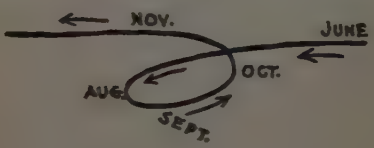
about as much detail on the surface of the Moon, as telescopic observations of Mars reveal.

The surface of Mars is actually of a reddish-ochre color, and the planet appears to the naked eye as a bright red star. When at a favorable opposition to the earth it rivals Jupiter in splendor.

The planet may be mistaken for the first magnitude stars, Antares in Scorpius, and Aldebaran in Taurus, near which it frequently passes.

The fixed stars, however, twinkle, while Mars glows steadily. If there is any doubt in the student's mind as to the identity of the planet, a few nights of observation, noting the changes in the planet's position, will decide the point.

As a rule, it takes Mars about fifty-seven days to pass over one constellation in the Zodiac, but at times its apparent movements are peculiar. It seems to stop, to retrace its steps for awhile, to stop again, and then to move once more forward in its proper west to east path. As we see it, it describes upon the celestial sphere an elongated loop as shown in the diagram.



This "retrograde" motion occurs only shortly before, during, and after an opposition, the time

Mars—*Continued*

when the Earth is between the Sun and Mars, and the planet rises at sunset. It is the effect of the Earth moving faster than Mars, and is similar to that experienced by a passenger in a train passing a slower one—the latter train appears to go backward.

For the Telescope

Because of its comparatively near approaches, and the clear visibility of its surface, Mars must ever be the most interesting planet for the observer, although the small glass reveals but little. The crescent phase never appears in planets which revolve outside the earth's orbit, but at times Mars appears gibbous like the moon, when it is three or four days from full.

At favorable oppositions, which occur once in fifteen or seventeen years, the more conspicuous dark markings, the "Hour Glass" or Kaiser Sea, and the polar snow caps, can be seen with a 3-inch glass. The so-called canals, concerning which there has been so much controversy, can only be seen with the largest telescopes.

A power of 200 is recommended.

THE ASTEROIDS

(or Planetoids)

These are a multitude of very small planets, revolving about the Sun between the orbits of Mars and Jupiter.

Their diameters range from probably a few yards, or less, up to about 500 miles.

Their distances from the Sun differ greatly—from about 135 million to over 400 million miles.

The largest four are, in the order of their discovery:

Ceres (1)	Diameter about		480	miles
Pallas (2)	"	"	300	"
Juno (3)	"	"	120	"
Vesta (4)	"	"	240	"
(the brightest)				

They revolve about the Sun in periods ranging from 687 days to about 9 years.

They form, in fact, a diffuse band or ring, comparable, except in size, in numbers and the density of the swarm, to the rings of the planet Saturn, later described.

Only one, Vesta, can be seen with the naked eye as a barely visible speck of light; and this only under the most favorable conditions.

The Asteroids—*Continued*

Many can be seen with a small telescope, and observers doing Variable Star work, where they are equipped with detail charts of small sections of the skies, often find upon these charts intruders not indicated. Such a stranger will almost certainly prove to be an asteroid. A few nights observation at the most will show a change of position, and an inquiry to Harvard College Observatory, giving as accurately as possible the observed position, will bring a reply identifying the asteroid.

The discovery of the asteroids was not a chance one. In 1772, an astronomer named Bode noted a certain regular "progression" in the distances of the planets from the Sun, and formulated Bode's "Law." Take the series of numbers 0, 3, 6, 12, 24, 48, 96, each number, except the second, being double the preceding one. Now add 4 to each number, and the series becomes 4, 7, 10, 16, 28, 52, 100. With the exception of the fifth (28), these numbers are closely proportional to the distances of the planets from the Sun: Mercury 3.9; Venus 7.2; Earth 10; Mars 15.2; ..... 28; Jupiter 52.9; Saturn 95.4. When in 1781, Herschel discovered the planet Uranus, and this was found to be at the distance appromixating the next number in the series, 196, the astronomical world decided to search for the planet that should fill the gap in the sequence. After a painstaking hunt, Piazzi, an Italian, located on the first night of the new century the asteroid later named Ceres.

The Asteroids—*Continued*

The other three noted above were discovered within the succeeding three years, and then no more until 1845. Since that date, the known number has increased rapidly, photography lending most efficient aid, until now more than one thousand are named and numbered.

It may be said that, while the discovery of the planet Neptune at a distance not in accord with Bode's Law proved this to be not a *Law*, there is little doubt that the sizes of the planets and the positions of their orbits were determined by inter-gravitational forces, and that the asteroids lie in a field in which the huge Jupiter refused to allow another planet of any size to form.

One of the little bodies, Eros, is of particular interest and value. This "worldlet" approaches the Earth at times nearer than any other celestial body except the Moon, meteors, and a rare comet. Its least distance from us is 13,500,000 miles. The value of these close approaches lies in the aid given to us in determining with greater accuracy the distance of the Earth from the Sun. Eros is too small to be measured with any degree of accuracy, but its diameter is believed to be not more than twenty miles.

JUPITER

Far beyond the orbit of Mars, and outside the ring of tiny asteroids, "the mighty planet Jupiter and his moons sweep splendid round the Sun." This giant among the planets, not only more than ten times in diameter, and 1300 times in bulk, the size of the Earth, but larger than all the other planets put together, is easily distinguished from the stars because of its brilliancy, exceeding in brightness all except Venus, and at times casting a perceptible shadow.

It moves slowly and majestically in its orbit, 483 millions of miles from the Sun, advancing through the twelve divisions of the Zodiac at the rate of one constellation yearly, and completing its revolution about the Sun in almost twelve years. It is, therefore, a simple matter to forecast its position, for, in whatever constellation it is seen now, it will, one year hence, be equally placed in the next figure of the Zodiac. Of course, this apparent slowness of motion is only due to distance, as Jupiter's real speed in its orbit is 8 miles per second.

A remarkable feature of this great body is its rapid rotation—9 hours and 55 minutes—giving it the shortest "day" of any of the planets. This speed requires that a point on the equator travel over 27,000 miles an hour. The result of

Jupiter—*Continued*

this terrific rotation, and the fact that the planet is but one and one-third times denser than water, is an obvious flattening at the poles and a corresponding bulge at the equator. The difference between the polar and the equatorial diameters of Jupiter is about 8,000 miles. In a telescope the oval shape of the planet is immediately evident.

Jupiter has nine satellites, only four of which can be seen except in the great telescopes. A good field glass will often show these four as tiny specks of light flanking the planet, and there have been partially substantiated cases of their being seen with the naked eye.

The details concerning all the moons are given in the tables in the appendix. It may be said here, however, that the four principal ones are as large as, or larger than, our Moon, and that the 8th and 9th moons, tiny bodies far distant from the parent planet, revolve in an opposite direction to all the others. The outermost moon of Saturn also has this retrograde motion, the explanation for which is still not known.

Historically, these moons have twice proved of great interest. They are the first celestial bodies discovered by Galileo with the first telescope; and through observations of their eclipses it was first indicated that light required time to travel.

Jupiter—*Continued*

For the Telescope

A power of 130 or thereabouts should be used. There is no difficulty in seeing the two principal belts, and the elliptical shape of the planet will be at once noted. It is even possible, when the atmospheric conditions are favorable, to see the different colors of the belts that cross the planet parallel to its equator.

The rapid rotation is clearly perceptible to the observer with a telescope on account of the diversified markings and colors of the moving disk, and to watch it is one of the greatest pleasures that the telescope affords.

The observation of the satellites of Jupiter will probably interest the amateur to a greater degree even than the view of the belts.

The four satellites, visible in our telescope, are named Io, Europa, Ganymede, and Callisto, beginning with the innermost, but they are generally referred to as I, II, III, and IV respectively.

So rapid are the changes in the positions of the satellites that the changes can be detected in a few hours of observation, and the amateur has a chance to verify the predictions as regards their respective positions in the ephemeris. Sometimes the four moons will appear on one side of the planet, and again two will appear on this side, and this ever-changing scene, that is quite unique and different from anything else

(*Continued on page 396.*)

Explanation of the Phenomena of Jupiter's Satellites

Let us suppose that Fig. 1 represents the view of Jupiter and his moons in the telescope using the celestial eyepiece;

To understand fully the real state of affairs let us consult Fig. 2. The observer is supposed to be at the point on the earth's orbit marked "A." As the plane of the orbits of Jupiter's moons is presented edgewise towards the earth, each moon appears to have the motion of a pendulum moving forward and back nearly in a straight line. At this precise time of our observation, I is between us and the planet, and in transit. As it is a bright object on a bright background it is practically invisible in our glass. Its shadow has not quite approached the point of ingress.

II is just to the right of the planet (the telescope reversing the true state of affairs) and is about to be occulted by the planet. It will be seen at once that on its reappearance from occultation it is immediately eclipsed, so that we have it disappear in occultation, and reappear from eclipse.

III is also at the right of the planet and actually at III but is visually projected to III.' Its shadow is in transit and the black dot of its shadow should be seen on the planet.

IV is to the left of the planet and about to be eclipsed.

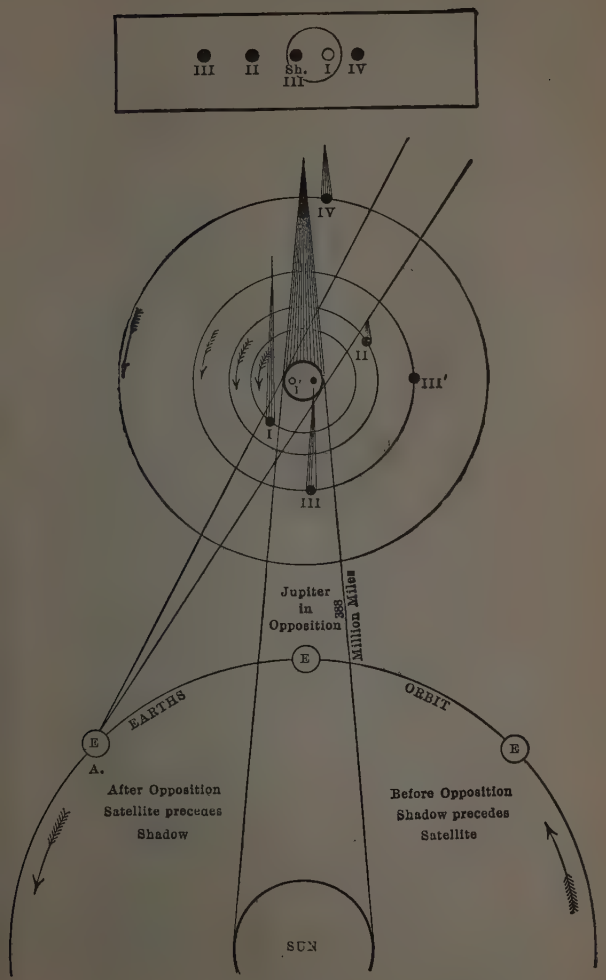

III
II
Sh.
III
I
IV
IV
II
III'
I
III
Jupiter
in
Opposition
388
MILLION MILES
E
EARTHS
ORBIT
E
E
A.
After Opposition
Satellite precedes
Shadow
Before Opposition
Shadow precedes
Satellite
SUN

Fig. 2

Jupiter—*Continued*

that human eyes behold, has a fascination about it that is peculiarly its own.

The sight of the eclipses, occultations, and transits of the satellites, and the transits of their shadows, is of unbounded interest. The view of transits of the moons is difficult for all save good instruments, but the shadows in transit are surprisingly distinct when the air is steady. The eclipses are accompanied by the phenomena of sudden disappearance and reappearance, and are of all the phenomena of the satellites most interesting to observe.

The Nautical Almanac contains full information regarding the phenomena of Jupiter's satellites. It may be obtained of the Superintendent of Documents, Washington, D. C.

THE LARGER SATELLITES OF JUPITER

	IO I	EUROPA II	GANYMEDE III	CALLISTO IV
Time of revolution	1d., 18h., 27m.	3d., 13h., 17m.	7d., 3h., 59m.	16d., 18h., 5m.
Diameter	2450	2050	3560	3350
Mean distance from planet	261,800	416,600	664,000	1,168,000
Characteristics	Rapid Motion	. . .	Largest and brightest	Greatest orbit
Colors	Straw color	White	Rosy orange	Steel gray
Stellar magnitude	5.5	5.7	5.1	6.3

SATURN

Until 1781, Saturn marked the boundary of the Sun's planetary system. It is easily distinguished from a star by the steadiness of its light, which is of a dull yellow hue, although to some it appears to have a slight greenish tinge like thinly beaten gold.

It swings slowly around its great orbit, 886 million miles from the Sun, taking about 29½ years to complete one revolution, and 2½ years to pass over one constellation of the Zodiac.

Like Jupiter this planet is a huge body, the diameter being about 72,000 miles, and also like the greatest of the planets Saturn's rotation is very rapid, 10 hours and 14 minutes. As the density of Saturn is small, *less* than that of water, this high speed of rotation produces a polar flattening even more marked than in the case of Jupiter.

Saturn is amply provided with moons, having ten of them. The largest one is about the size of the planet Mercury, and can, under very favorable conditions, be seen with a good field glass.

The celebrated, and unique, rings are the outstanding features of Saturn. These rings are not solid masses, as they appear, and as they were believed to be for a long time after their

Saturn—*Continued*

discovery, but are swarms of countless tiny "moonlets" so close together that they are individually indistinguishable. They, of course, shine by reflected sunlight only as do the larger satellites.

The tables given below and in the appendix present the statistics of the moons and the rings.

For the Telescope

Saturn ranks next to Jupiter in offering attractive and easy observational features.

Under favorable conditions we can see the belts on the surface of the planet with our glass. The observer will at once perceive the elliptical appearance of the planet, as with Jupiter.

The rings are clearly visible and present a marvellous sight. With a high power, it will be seen that the seemingly solid band of light is divided into two rings. The dark line separating these is called, after its discoverer, Cassini's division. A division in the outer ring, Encke's division, and the third inner ring, called the "crepe" ring because of its apparent texture, are visible only in the great telescopes.

From a combination of circumstances, Saturn alternately exhibits each side to the earth, and the rings appear to increase and decrease in breadth. This phenomenon is gone through in a little less than fifteen years for each side of the rings. In 1907, because of the edge presentation of the rings, they were invisible in a small telescope. In a large telescope the rings at such

SATURN

December 23, 1912. Note the dark cap, the belts, the divisions in the rings, and the oval form of the planet

From photographs by E. C. Slipher, taken at the Lowell Observatory

a time resemble "a pair of illuminated needles stuck into the ball of the planet on opposite sides."

Approximate Positions of Saturn's Rings
(Redrawn from Todd's *New Astronomy*)

The rings were first seen by Galileo, in 1610, but, as they were not favorably placed, his glass was not powerful enough to show them clearly. As they were approaching their edge presentation, they soon disappeared from sight, and Galileo died believing them to have been illusionary. It was not until 1855 that Huyghens, a Dutch astronomer, determined that they were rings.

Saturn—*Continued*

The largest moons, Titan (in appearance like an eighth magnitude star) and Japetus, can be readily seen, and under good seeing conditions, Rhea, Tethys, and Dione, moons still nearer to the planet, can be glimpsed, but the comparatively sluggish movements of these attendants of Saturn render them uninteresting as compared with those of Jupiter. To see Tethys and Dione the planet should be screened from view.

SATURN'S MOONS VISIBLE IN A SMALL TELESCOPE

Name	*Mean Distance from Planet in Miles*	*Period of Revolution*			*Diameter in Miles*
		Da.	*Hrs.*	*Min.*	
Titan	758,800	15	22	41	2625
Iapetus	2,210,000	79	7	56	1125 (?)

	Diameter in Miles	*Breadth in Miles*
Outer Ring	172,400	10,900
Cassini Division	..	2,300
Second Ring	146,000	18,000
Crepe Ring	100,000 (?)	11,000 (?)

Thickness of rings is estimated to be 100 miles.

Width of whole ring system is 42,741 miles.

There is a distance of 5900 miles between the inner edge of the rings and the planet's equator.

A graphic idea of the width of the rings can be obtained by imagining the Earth rolling like a marble around the outer and crepe rings, and **two Earths, side by side,** on the second ring.

URANUS

Uranus is the fourth from largest of the planets, and is the seventh in order from the Sun, about which it revolves at a distance of 1,800 million miles—19 times as far away as the Earth.

Because of its distance it is difficult to measure the exact diameter which is somewhere between 28,500 and 35,000 miles. We do know that its mass is 14½ times that of the Earth, and that it is just heavier than water.

It takes about 84 years to complete a revolution round the Sun, but its time of rotation—its day—is not definitely known.

Uranus is accompanied by four moons, the descriptions of which are in the appendix tables.

Uranus was the first planet ever *discovered*. All the others have been known since history began. It was found accidentally by Sir William Herschel, in 1781, while "sweeping" the heavens for what he might find with a telescope of his own manufacture. At first, though seeing immediately that it was not a star, its true nature did not occur to him; no one had ever thought of a new planet. For some time it was studied as a comet, and it was not until almost a year later that it was properly classified.

At its nearest approach to the Earth, it shines as a faint "star" (about sixth magnitude) of

Uranus—*Continued*

slightly greenish tint, and under the most favorable conditions is just visible to good eyes.

For the Telescope

Uranus is too distant to offer any features of interest to the observer with a small glass, although it can be picked up easily with a field glass and seen very well with a three-inch telescope.

It will be recognized in a telescope at once because of the absence of the diffraction ring which always encircles the star image in a good telescope. The disk of Uranus appears pale and diffused, that of a star is sharp and brilliant. The almanac is indispensable in locating it.

NEPTUNE

As far as is now known, Neptune patrols, at the vast distance of 2,800 million miles, the frontiers of the solar system. It is probably somewhat smaller than Uranus, but of a slightly higher density. The two planets are comparatively similar, as are Venus and the Earth.

The rotation time is in doubt, but its slow orbital speed, 3½ miles per second, requires 164 of our years to carry it through one revolution about the Sun. Neptune takes nearly fourteen years, therefore, to traverse each zodiacal constellation.

It has one moon, visible only in large telescopes, which was discovered within a month of the planet itself.

Neptune is never seen with the naked eye, and in a three-inch telescope resembles an eighth magnitude star. An exact knowledge of its position (obtainable from the Nautical Almanac) is indispensable in identifying it.

Neptune receives from the Sun only a wretchedly small proportionate share of light and heat, about 1/1000 of that which illuminates and warms the Earth. Unless, therefore, the planet is intrinsically warm, the surface temperature must be cold beyond description. Do not think, however, that there is no real daylight on

Neptune—*Continued*

Neptune. The Sun, though appearing so small as not to be seen as a real disk by the naked eye, nevertheless gives as much light to the planet as about 700 of our full moons. "As seen from Neptune, the Sun would look like a brilliant arc-lamp at a distance of a few yards."

The discovery of Neptune, in 1846, marked the great triumph of mathematical astronomy. Uranus had failed to move in its orbit precisely as predicted, and astronomers were at a loss to explain the fault. The difference between the predicted and the actual positions was extremely slight from a naked eye view-point, but that there was a difference showed that something was wrong. Two men, Adams of England, and Leverrier of France, independently took up the solution of the problem, and not only each arrived at the conclusion that a planet exterior to Uranus was causing the perturbations of the latter, but each computed with amazing accuracy the position of this hypothetical body. Leverrier sent his calculations to Galle, in Berlin, who had just finished mapping the stars in the region where the mathematician's results placed the new planet. It took but the shortest time for the astronomer to find Neptune, within less than a degree (twice the width of a full Moon) of the predicted spot.

For many years Adams was not given due credit for his marvellous labor, since, though his calculations were completed months before those of Leverrier, the Astronomer Royal of

Neptune *Continued*

England, to whom Adams sent his figures, was too methodical a man to take up the search for this supposed planet until it was too late to be the first. Now, of course, the scientific world agrees that the two men fairly share the great honor.

OTHER PLANETS

For some time, there was believed to be a planet revolving about the Sun within the orbit of Mercury. Several actual observations of it were reported, and it was even given a name, Vulcan. Its existence has now, however, been absolutely disproved.

Also, far beyond Neptune, another planet (possibly two) is supposed to creep in its slow path. A systematic search for this has extended over many years, but has as yet been unsuccessful. If such a planet does exist, as seems not unlikely, it must be at a vast distance, and visually be very faint. If found, it will unquestionably be the photographic plate that first "sees" it, and records its lazy motion across the skies.

COMETS

Comets are defined as celestial bodies which move about the sun in greatly elongated orbits, usually elliptical, sometimes, perhaps, parabolic or hyperbolic. The word "Comet" is derived from the Greek κομήτης, meaning long-haired, which is descriptive of a comet's streaming tail.

Comets usually appear suddenly in the sky, change their form and brightness nightly as they near the sun, and then disappear from view, to return, if their orbits are elliptical, years hence.

In appearance, they are hazy starlike-looking objects that frequently, but not always, develop a luminous appendage.

This *always points away from the sun*, and its length varies from two to ninety degrees.

Comets are composed of three parts: the nucleus, the coma, and the tail. The nucleus is the most condensed part of the comet's head. It is surrounded by a nebulous light giving the nucleus a hazy and misty appearance, which is called the coma. The tail is the train of tenuous gaseous matter, the chief glory of the comet, which may, or may not be present.

In the case of faint telescopic comets, the coma is all that is observed, and no evidence of a nucleus or tail can be seen. It is merely a hazy

patch of light in the sky, resembling a faint nebula. These comets are known as "telescopic comets."

For a long time, it was thought that the majority of comets moved in parabolic orbits. Hevelius, in 1675, was the first to suggest that the orbits of comets might be parabolic. This was believed proved by his pupil, Doerfel, for the comet of 1681.

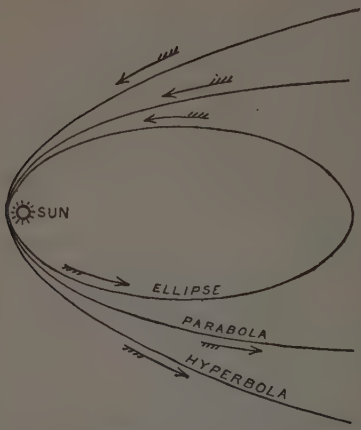
The discovery that some comets move in elliptical orbits, and hence return to the sun at periodic intervals, was first announced by Halley in 1682, when he predicted that the comet of that year would return again in 1758. Knowing that he would not live to witness the fulfillment of the prediction, he expressed a modest hope, that, if the comet should return as predicted, that "posterity would not refuse to acknowledge that this was discovered by an Englishman."

His hope was fulfilled, and Halley's name ranks among the immortals. Halley's Comet was observed many times before his day. Its earliest recorded appearance is supposed to be that of 240 B.C. Its appearance in 1066 is depicted on the famous Bayeux tapestry, undoubtedly the earliest delineation of the comet.

It is now the general belief that probably all comets are members of the solar system.

Of comets with proved elliptical orbits, fifty have been found to have periods less than 100 years. There are twenty comets with periods ranging from 100 to 1000 years, and thirty more

with periods between 1000 and 10,000 years. (Russell.)



ELLIPSE, PARABOLA, AND HYPERBOLA

The figure shows graphically why it is so difficult to tell exactly the form of a comet's orbit. The three kinds of curves are nearly of the same form near the focus (the Sun), and it is only in that part of its orbit that the comet can be seen. Moreover a comet is, at best, a misty and indefinite object, which renders it so much the more difficult to obtain good observations of its precise position and movement.

As the comet approaches the sun, the nucleus takes form, but is never sharply defined, because of the misty light of the coma surrounding it. The tail extends as if repelled by some solar influence, often with great velocity. Changes in the form of a comet's tail have been observed in 24 hour intervals, the tail taking sometimes the form of a gigantic scimitar or fan.

The nucleus of a bright comet, as it nears the sun, often appears to expand, in a succession of bright enveloping rings, that stream backward, and become a part of the tail, much as water streams back to the wake from the prow of broad-nosed vessels in motion.

The matter composing comets must be tenuous in the extreme, as stars are observed to glow with undiminished light when the comet passes over them.

It is now pretty well established that the head of a comet is not composed of a solid condensed mass, but is made up of separate and detached particles of matter. The mass of a comet is insignificant, and, in no case, as great as that of the smallest of the planets.

Schiaparelli was the first to announce the connection between comets and meteors, a fact well established today. He proved the agreement between the orbit of the comet of 1862 and that of the meteor shower seen annually, about August 11th, the shower now known as "the Perseids."

Comets have always been objects of superstitious fear. From remote times they have been considered ill omens that presaged disaster to mankind.

To date, we have a record of over nine hundred comets. Four hundred of these appeared before the invention of the telescope in 1609. Since 1880 an average of over five comets a year have been discovered. The first comet discovered by photography was discovered by Barnard in 1892. In 1895 eleven comets were discovered,

the greatest number discovered in any one year.

La Place was the first to suggest that the orbits of comets that approached the giant planet Jupiter were likely to be diverted from their path, and captured, so to speak, by that planet. This theory is now generally accepted. According to Professor Russell, most of the short period comets can hardly be regarded as permanent members of that group, since their orbits may be radically altered by encounters with planetary influences.

The planets Saturn and Uranus have also families of comets which they have annexed, but they are not as numerous as Jupiter's family.

Of late years there has been considerable controversy over the question of the origin of comets, whether they are a part of the solar system, or of the region that lies outside it. The former view is the generally accepted one today.

A word as to the dimensions of a comet. As a rule the coma is from 30,000 to 150,000 miles in diameter. The average diameter tabulated by Holestschek is 80,000 miles.[1] The comet of 1811 was an enormous body having a coma estimated to be a million miles in diameter.

The nucleus of a comet, on the average, is in the neighborhood of one thousand miles in diameter. The tail of the comet is its most spectacular feature, and a tremendous affair. Professor Russell tells us that a comet's tail, visible to the naked eye, is seldom less than five or ten million miles long, and lengths of from

[1] *Astronomy*, Russell Dugan, Stewart.

thirty to fifty million miles are not uncommon among bright comets. There are cases where the tail of a comet fully 100 million miles long have been observed.

The light of a comet varies enormously. Some are barely visible in the great telescopes, others have exceeded in brightness all celestial bodies except the sun and moon. The spectroscope shows that the light from the head of a comet is partly due to reflected sunlight, and partly by the light emitted from the gaseous envelope surrounding it.

The tail of a comet shows that its light is partly due to reflected sunlight, and the spectrum includes bands identified with those of carbon monoxide at exceedingly low pressure.

As regards the probability and effect of a collision between the earth and a comet, often a matter of popular concern, it may be said that there is little chance of such an occurrence. If it did happen there is little likelihood of disastrous consequences to the earth's inhabitants. The chances are that the effect of such a collision would merely produce a magnificent meteoric display.

As for the matter of danger from the gases composing a comet's tail, the earth has already passed through the tails of comets without causing any ill effects to its inhabitants.

Brilliant comets are unfortunately rare. They are glorious objects, and should be viewed as such. Only the ignorant and superstitious fear them.

METEORS

Celestial objects, popularly known as "shooting stars," have been noted by everyone. Frequently they are extremely brilliant, and excite the attention of all observers.

We now know that these swift flashing objects are not stars in motion at all, but bodies that are close to us, comparatively speaking, attracted to the earth by the force of gravitation. These objects are called "meteors," and the phenomena of their appearance, motion, and direction of flight have been closely studied for many years, and we are now able to classify them.

The faint meteors that make mere streaks in the sky, and vanish almost instantly, are the most numerous. Meteors that are of unusual brilliance are known as "Fire-Balls," or "Bolides." These objects often move slowly and majestically across the heavens, and sometimes explode, the particles glowing in the sky for some seconds, and displaying many beautiful colors, due to the burning elements composing them.

The rapidity of the speed of a meteor's flight is at once a clue to its distance from us. We know that none of these bodies are far from us, for when they are first observed they are approximately 75 miles away. They vanish

from our sight at a distance of about 50 miles after an average flight of 35 miles, and their speed is something like 27 miles a second. There are, of course, exceptions to this rate of speed in the case of bolides. The velocity of the Earth, and the direction of the meteor's approach must be taken into account in judging of the meteor's speed of flight. Meteors that come for us head on, move at a speed of from 14 to 45 miles a second. In some instances, they have been calculated to dart through our atmosphere at the rate of 100 miles a second.

Meteors are visible to us for the reason that, as they rush toward the Earth, they come in contact with the Earth's atmosphere. The friction caused by the encounter ignites them, and they hurtle across the sky flaming as they go, leaving a trail of incandescent particles of matter in their wake. Sometimes this trail persists for some seconds, and the trails assume curiously twisted forms. Generally, however, the trails vanish almost instantly, so small are the particles composing them, the ashes sift down gradually to the Earth's surface, and meteoric particles are found even on the virgin snow that mantles our lofty mountain peaks.

When the meteor is of considerable size, the heat generated in the body is not sufficient to destroy it utterly. A residue of the original meteor survives the conflagration and buries itself in the earth or sea. These fragments of meteors that reach the earth are called "Meteorites." Many of them have been recovered and placed in museums, where they are

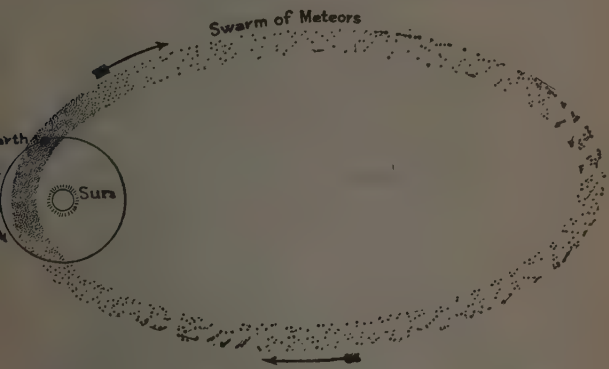
objects of study and interest. Meteorites range in size from small particles to massive fragments weighing tons. Admiral Peary brought back a meteorite from Greenland, which he presented to the Museum of Natural History in New York City. It weighs 36 tons. As this is being written there comes the report from Russia of the discovery of a monster meteorite in the wilds of Siberia. It is estimated to weigh 40,000 tons, and in its fall leveled and charred a forest fifteen miles in circumference. It pitted the ground with deep tunnels fifty to one hundred feet wide, and is beyond doubt the largest meteoric mass yet reported.

No part of the sky is free from meteors. In certain parts of the heavens, at definite dates annually, there are what is known as "Showers of Meteors" when great numbers of meteors are seen in a short period of time. There was a very remarkable meteor shower that radiated from the sickle in the constellation Leo, in 1833 and again in 1866, when, it is said, the sky rained stars. This shower is known as "the Leonids."

The reason that meteor showers appear to radiate from a definite point in the heavens, spreading out from a common center like a fan in all directions, is purely a matter of perspective, an illusion similar to that of the converging of railway tracks on a long straightaway, where they seem to end in a point. The meteors are actually falling in parallel courses that seem directed from their radiant or vanishing point.

It has been discovered that comets are asso-

ciated with meteors, for the reason that when some expected comet has failed to appear we have observed, instead, a shower of meteors. This was the case with the great meteor shower mentioned above that radiated from Leo. The shower known as "the Andromedids," because they appear in the constellation Andromeda, is in the track or orbit formerly followed by Biela's



A Diagram of a Stream of Meteors showing the Earth passing through them.

comet, which split into two parts, that traveled together until their next return. After that they were never seen again, but at the scheduled times of return there have been brilliant displays of meteors. There seems little doubt but that these are the fragments of the disintegrated comet.

The Earth in its annual orbital motion about the sun encounters these swarms of meteors at definite dates in the year, and definite positions

on its orbit where the meteors are streaming, and then the Earth is peppered by them. In a few days or weeks, as the case may be, the Earth passes the zone of the shower, and the shower is over till another year.

The regularity of the occurrences of the well known meteoric showers leads us to the conclusion that these swarms of meteors are moving in elliptical orbits, and are a part of the solar system. It may also be that a certain proportion of meteors are moving in hyperbolic or parabolic orbits. In these cases the meteors come from and return to interstellar space unless they are attracted and thrown, by planetary influences, into elliptical orbits.

It has been estimated that the number of meteors visible to the naked eye in twenty-four hours must be several millions. Double the number of meteors are seen after midnight than are observed during the hours before midnight. The reason for this is that in the early morning hours, owing to the Earth's diurnal motion, we are facing our course and see the meteors overtaking us as well as those coming head on. In the early evening hours we only see the meteors that are chasing us.

A word as regards the constitution of meteors. Owing to the recovery of many meteorites we have had an opportunity of analyzing them qualitatively and quantitatively. The majority of meteorites are composed of stone, many are masses of metallic iron, alloyed with nickel and cobalt. About thirty of the chemical elements have been found in these bodies, the most abun-

dant being in order respectively, iron, oxygen, nickel, silicon, and magnesium.

Valuable scientific work can be done by the amateur by seriously undertaking the study of meteors. All that is required is time, patience, and a knowledge of the constellations. Anyone wishing to engage in such work should write the Headquarters of the American Meteor Society, Flower Observatory, Univ. of Penn., and the necessary instructions for observing will be sent.

The photographing of meteor trails offers the amateur a splendid opportunity for aiding Science. Data of real scientific value can be obtained by anyone who will engage in this fascinating work. Those interested should write Dr. Willard J. Fisher, Harvard College Observatory, for information and instructions for carrying on this work.

In conclusion, reference must be made to a remarkable crater in Arizona near Cañon Diablo, known as "Coon Butte." Here there has been discovered a circular depression 400 feet in diameter and about 600 feet deep. On the northern rim of the crater masses of partially oxidized meteoric iron have been found.

It is thought that this crater was formed by the impact of a gigantic meteor. Borings have been made in the floor of the crater to a depth of 700 feet. Meteoric material has been encountered in these borings from two hundred to six hundred feet levels. The work is still being carried on, and there is reason to believe that in the near future the mystery of this unusual formation will be solved.

Historical

The records relating to meteors may be traced back fully 2500 years. In the Book of Joshua, 10:11, it is related that the Lord cast down great stones from heaven. This is thought to be a reference to a meteoric shower.

In Chinese annals for 687 B.C. there is a reference to meteors, and another is to be found in Pliny to 467 B.C. The Phrygian stone carried to Rome in 204 B.C. was doubtless a meteorite, and the sacred stone within the Kaaba, at Mecca, the Mohammedan's Holy of Holies, is another.

The oldest meteorite preserved which is absolutely authentic, fell November 7, 1492, near Ensisheim, Alsace. "Its fall was accompanied by a loud clap of thunder, and a prolonged confused noise." In 1790, and again in 1803, showers of stones fell in small towns in France.

The Leonid meteors afforded magnificent and sublime displays in 1833 and 1866.

The serious study of meteors dates back to 1794 when Chaldni published a memoir on the subject. Brandes and Benzenberg, students at Göttingen, were assiduous observers of meteors in 1798, and the former continued the work in 1823.

Systematic study of meteors is of comparatively recent date. This has been carried on

chiefly by Dr. W. F. Deening in England, and Dr. Chas. P. Olivier in our own country. The latter is the President of the American Meteor Society, an organization of enthusiastic observers who are accomplishing results of scientific value on the subject.

The following list[1] contains the principal meteoric showers occurring annually. The R.A. (Right Ascension) and D. (Declination) of the radiant points are given to aid in their definite location. The student should plot these positions on a Star Atlas.

The radiant points of the three showers marked with a "*" are not established with certainty.

Name of Shower	*Date*	*Radiant Point* *R.A.*	*D.*	*Remarks*
Quadrantids	Jan. 3	230	+52	Slowish, long paths.
Lyrids	Apr. 20	277	+34	Swift streaks.
η Aquarids	May 2	332	− 1	Swift, very long paths.
*δ Aquarids	Jly. 28–30	339	−12	Slow, long paths.
*α Capricornids	Jly. 25–Aug. 4	303	−10	Very slow, brilliant, long paths.
Perseids	Aug. 11	44	+56	Swift streaks.
Orionids	Oct. 19	11	+15	Swift streaks.
Leonids	Nov. 14	150	+23	Very swift streaks.
*Andromedids	Nov. 17–27	25	+44	Very slow, short trains.
Geminids	Dec. 12	112	+33	Swift, white, short paths.

Further details concerning the more important of the showers are given on the following pages.

[1] The author gratefully acknowledges the assistance rendered by Dr. Chas. P. Olivier, in the preparation of the above list.

The Lyrids

The meteoric shower, known as "the Lyrids," that radiates from this constellation, is one of the few conspicuous showers of the year. The meteors should be looked for the night of April 20th at a late hour. The radiant point is due south of Vega, and on a line with beta and gamma Lyræ. These meteors are white in color, and noted for the swiftness of their motion. They are thought to be connected with the comet of 1861.

Observers of meteors should count the number seen per hour, record the time of the observation of a meteor, note its direction of flight, its position when first seen and where it vanished, and make a rough estimate of its brightness in terms of stellar magnitude. These facts should be recorded in an observing book, and the data sent to Professor Chas. P. Olivier, Flower Observatory, University of Pennsylvania.

By making such observations any one, with little trouble, can contribute valuable scientific data, and assist materially in the great research work that is being carried on.

The Perseids

A noted meteor shower, called "the Perseids," radiates from this constellation. The meteors should be looked for August 11th and 12th. The radiant point is in the vicinity of γ Persei. These meteors are sometimes called "the Tears of St. Lawrence." They dart with great swiftness across the sky, and are yellow in color. They are known to be traveling in the same orbit as that of Tuttle's comet of 1862, and are probably associated with it. The average number of meteors in this shower visible per hour is sixty-nine.

The Leonids

November is a famous month for meteors. A shower known as "the Leonids" radiates from the head of the Lion, marked by the sickle. It is due on the 14th or 15th of the month. These meteors were wonderfully numerous in 1833 and 1866, when there were marvelous displays. Since then they have not been seen in such vast numbers.

Calculations show that this great meteoric swarm has been drawn aside from its orbit by the attraction of the planets Jupiter and Saturn.

The Leonids are remarkable for their swiftness, and their light is of a deep bluish color. They are following about the sun the exact path of Tempel's Comet, and it is thought that they are the remains of this Comet.

In the center of the constellation Leo, about midway between the sickle and the triangle, will be found one of the starless regions of the sky.

The Andromedids (or Bielids)

The star γ Andromedæ marks the radiant point of the Bielid meteors associated with Biela's comet, which disappeared in the first half of the 19th Century. These meteors should be looked for on November nights between the 17th and 27th of the month. The stream travels very slowly, and the meteors are characterized by their yellowish color and their short trains.

The Orionids

A well known meteor shower occurs each year in this region, known as "the Orionids." The meteors should be looked for the night of October 19th. A line drawn from Rigel to Betelgeuze, prolonged half its length, locates the radiant point of the shower.

ECLIPSES

Eclipses were probably among the very first celestial phenomena to be studied. We have records of them dating back several thousand years.

That an eclipse of the Sun is caused by the Moon passing between it and the Earth, and that an eclipse of the Moon is caused by the latter entering the great shadow the Earth casts into space, is too well known to require any space here.

The plane of the orbit of the Moon around the Earth is inclined, or tilted, to the plane of the ecliptic, i.e., the plane of the Earth's orbit around the Sun. It is only when the Moon is at, or near, one of the points where its orbit cuts the plane of the ecliptic, and simultaneously, the Sun, also, is apparently at, or sufficiently close to, one of them that an eclipse can occur. It is for this reason that the plane of the Earth's orbit is called the ecliptic. In one year there may be as many as seven eclipses, five of the Sun and two of the Moon, or four of the Sun and three of the Moon; or as few as two eclipses but never less. When there are but two eclipses these both *must be* of the Sun. The Moon is never eclipsed more than three times in a year.

There is a certain time cycle, of about 18 years, called the Saros, at the end of which

begins a repetition of eclipses similar to those of the previous 18 years. This Saros was known to the Chaldeans. It is not exact, but is close enough to be of practical value.

The reasons for the above are all technical and mathematical, and, as such, have no place here.

Eclipses of the Sun are more numerous than those of the Moon in a ratio of about three to two, but, from any given point on the Earth more eclipses of the Moon may be seen than those of the Sun. A solar eclipse, because of the small width of the Moon's shadow, can be seen from only a limited position of the Earth, but an eclipse of the Moon can be seen from a whole hemisphere at the same time.

Eclipses may be roughly divided into two main classes, total and partial.

Eclipses of the Sun

A total eclipse of the Sun is visible from some point on the Earth about once every year and a half. At any given place, however, one is seen only about once every 360 years. This is because of the narrowness of the Moon's shadow, which averages about sixty to seventy miles in width.

An eclipse is called total when the Moon's disk entirely covers that of the Sun. Because of the varying distances of the Moon from the Earth, and the Earth, (and consequently the Moon, too) from the Sun, the apparent sizes of the Moon and the Sun vary. There are, there-

fore, eclipses where the solar disk is barely covered, and others where it is completely screened. The total stage of solar eclipse can last, at most, only about eight minutes. The shadow of the Moon travels at the Earth's surface with the speed of a cannon ball, and only under the best conditions can an eight-minute totality occur. This can happen only at the Equator, and at the very center of the path of 168 miles in width made by the Moon's shadow when broadest.

It is only during the total stage that the wonderful Solar Corona is seen.

Whenever a total eclipse occurs it may be seen also as a partial eclipse on a strip of the Earth's surface several hundred miles on either side of the path of totality.

An eclipse of the Sun where the disk is not covered entirely although the Moon is passing directly between the observer and the Sun, or centrally as it is termed, is called an annular eclipse because of the ring (Latin, *annulus*) of the Sun's rim left shining around the black disk of the Moon. An annular eclipse occurs when the Moon is farthest from the Earth, and the Earth and Moon are nearest the Sun, and in consequence, the shadow of the Moon is not long enough to reach the Earth. The annular eclipse is, of course, only a special form of partial eclipse.

The third form of the solar eclipse is the partial type. This occurs when the Moon passes over the Sun's disk not centrally. It may range from an almost total eclipse to a bare shading of the Sun's rim.

The total eclipses are those of greatest astronomical interest.

One value of a total solar eclipse lies in the opportunity it gives for studying the wonderful Corona about which so very little is known. Many expeditions are nearly always sent out to that part of the world from which a predicted total solar eclipse will probably best be observed. It is, of course, a great gamble, for a few moments of cloud may render useless the preparation and expense of months. During the totality, but little attention is, nowadays, paid to direct observing, all efforts being centered upon obtaining as many good photographs as possible.

Until the spectroscope proved its ability to view them under ordinary conditions, the study of the Solar Prominences was also restricted to the scant few moments of totality during an eclipse.

In recent years, a factor of paramount interest has been added to the total solar eclipse: a test of the Relativity Theory.

According to Einstein, the light of a star passing close to a massive body like the Sun, and through its powerful "field," is bent into a curved path, and, therefore, the observed position of the star is slightly different from the actual position. Einstein predicted the exact amount of this difference.

The principle of the test is, roughly:

Two sets of photographs are made, one, long before, of the stars surrounding the position the Sun will occupy during totality, the other during the totality, when the same stars can be seen shining close to the black disk of the obscuring

Moon. The photographs are then carefully compared. Theoretically, the star images during totality should all appear shifted away from the Sun to a small amount; but, while the relativitists hail the published results of the tests as complete confirmations of Einstein, the facts are that the shifts of the stellar images *are by no means consistent, either in amount or direction*, and the results can be brought into accord with those predicted only by "forcing an average."

It is to be deplored that the supporters of Relativity, a remarkably logical and epoch-making conception, for it is probably fundamentally correct, should have laid themselves and the theory open to a justified scepticism by their over-eagerness to present the world with a "proof" that later investigations show to be doubtful in the extreme.

The fact that the eclipse plates do not bring definite corroboration, in no way suggests a *disproof* of the Theory. So many factors must be taken into consideration in connection with such measurements that the true causes of the observed shifts and their apparent inconsistency will be indeed difficult to identify. Einstein may well be correct, but the eclipse records thus far obtained do not accord his Theory an iota of true *proof*.

Eclipses of the Moon

These are either total or partial. A total eclipse of the Moon occurs when it passes entirely into the shadow of the Earth. The diameter of the Earth's shadow where the Moon

crosses it is about 5700 miles. The Moon, therefore, with a diameter of 2160 miles, can be quite "out of line" and still be totally eclipsed. When the Moon crosses the center of the shadow the total phase lasts about two hours. The duration of a non-central eclipse varies according to what part of the shadow is traversed.

Owing to the refractive power of the Earth's atmosphere, the rays of the Sun are somewhat bent around the Earth, so that its shadow is never clearly defined, as is that of the Moon; and, even when the latter is totally immersed in the Earth's shadow, its disk is usually visible, glowing with a dull, copper-colored light. The color is caused by the passage of the Sun's rays through such an extent of our atmosphere. From the Moon, during a total lunar eclipse, the Earth must appear as a great black disk rounded by a narrow ring of brilliant light, colored with sunset tints. In 1884, the cloudy condition of the Earth's atmosphere prevented the passage of practically all this refracted light, and the Moon for a time was quite invisible to the naked eye; a most unusual occurrence.

A partial eclipse of the Moon occurs when the edge of the Earth's shadow only is traversed. Like a partial eclipse of the Sun, it may range from the barest touching of the Moon's edge up to an almost total phase.

Lunar eclipses offer little of special interest.

The ability to reckon backward for centuries eclipses of both the Sun and the Moon aids greatly in fixing historical dates of events occurring near eclipses mentioned in old records.

THE MILKY WAY

The Milky Way, or Galaxy, is a vast, irregular belt of luminosity that nearly encompasses the heavens. It covers more than one-tenth of the visible heavens, and passes through the constellations Cassiopeia, Cepheus, Perseus, Auriga, Monoceros, part of Orion, Gemini, Argo, Crux, Centaurus, Scorpius, Sagittarius, Aquila, Delphinus, and Cygnus.

This remarkable feature of the celestial sphere is composed of stars, billions of them, at such a remote distance from us that their light is merged into the semblance of glowing clouds.

To Democritus, the Greek philosopher, is due the honor of first advancing the theory that the misty light of the Galaxy was due to the combined light of innumerable faint stars. Galileo, in 1610, with his newly invented telescope, confirmed this view. Now we have marvelous photographs taken with our giant telescopes that reveal the glories of this stupendous assemblage of suns.

So rich are the star fields in the Milky Way, we are informed by that prince of observers, Sir William Herschel, that in one quarter of an hour no less than 116,000 stars passed in review across his telescopic field of vision.

The Milky Way has been intensively studied

by astronomers of late years. It has been found that it varies in brightness in different regions, and it is crossed in many places, particularly in Cygnus and Sagittarius, by dark irregular areas. These features have been called "Coal Sacks," and for many years they were thought to be starless regions, windows in the sky, so to speak, through which mankind peered into interstellar space beyond.

We now know that these dark patches in the Galaxy are really opaque clouds of cosmic matter, "dark nebulæ," perhaps the elemental principle of the cosmos that marks the first, or last, step in stellar evolution. These clouds of obscuring matter shut out from our view the light of the more remote stars. A remarkable dark nebula has been photographed by Professor Duncan, situated in the constellation Orion, near the star zeta Orionis. The photograph shows a jet black object with sharply defined edges, and the resemblance to a cloud is unmistakable. The dimensions of these clouds must be exceedingly great.

There have been many attempts to estimate the number of stars in the stellar system—the Galaxy we call ours. Totals ranging from 3,000 millions to 30,000 millions are sometimes given, often less. The gathering of the stars in the plane of the Milky Way presents the difficulty that makes all estimates largely guesswork; for, in the direction of that plane, "there lie stars behind stars until vision fails."

The Milky Way has long been considered as

the framework of the sidereal universe, "closely connected with the entire constitution of our stellar system." This view was advanced by Thomas Wright as early as 1750, who held that the Milky Way is roughly in the form of a disk, the Sun being somewhere near the centre.

It was the determined and remarkable research work of Kapteyn that gave corroboration to this theory. By carefully estimating the distribution of the stars throughout space, he was able to demonstrate the probability of this disk-shaped system, and the "Kapteyn Universe" became an accepted belief.

The past few years have, however, brought rapid advances in this field of astronomical knowledge, and Shapley now tells us that the "Kapteyn Universe" is only a "local star-cloud," that is part of a still greater system, "probably coiled in spiral form like the spiral nebulæ which are observed in great numbers in the heavens." (Eddington.) Shapley has estimated the location of the center of this greater Galaxy, and places it somewhere in the direction of the constellation Sagittarius, about 25,000 light-years distant. This vast system is also disk-shaped, due to rapid rotation, of which there is direct evidence.

Our local cluster—the "Kapteyn Universe"—is now estimated to be at least 2,000 light years across; but the greater Galactic system can scarcely be less than 300,000 light years in diameter.

It is a far cry from the geocentric universe, in which Sun, Moon and Stars were but the atten-

dants upon man's Earth, to a cosmos where "the galactic system is one among a million or more spiral nebulæ"—other universes, the nearest of which is 850,000 light years away.

How far does this go on—atoms forming molecules, molecules building suns, suns swarming into clusters, clusters gathering into "universes," and—universes into an atom of a superphysics?? Is there a limit to size—to space? Einstein claims that there is. There is, at least, not enough here to discuss the question. If any reader is interested, however, let him turn with the anticipation of great pleasure to the reading of Eddington's "Nature of the Physical World."

To some, the contemplation of the overwhelming vastnesses of stellar systems, of universes—of *systems of universes*,—is terrifying beyond measure. This should not be. Let man realize that "in the eternity of duration his life is the dream of a moment, and bow his head in reverence before the Immeasurable Power which finds expression in this infinite profusion of shining suns"; but let him raise his head again in proud amazement at the greater wonder: that he can seize and hold this mighty immensity in the grasp of his tiny brain.

Mythology

Of all the marvels of the firmament, the Milky Way stands preeminent, exciting the admiration and wonder of all beholders.

A wealth of myth and legend has been be-

queathed to us contributed by men of every race from time immemorial.

In ancient Judea, and Armenia, the Milky Way was regarded as a Long Bandage wrapped around the heavens. The Greeks knew it as "the Road to the Palace of Heaven." The Algonquin Indians imagined it was the path of departed souls, and the bright stars along the way were camp fires built by the departed as they journeyed toward their eternal home.

The Peruvians and Incas thought that the Milky Way was composed of star-dust. The Egyptians imagined that the Galaxy was formed by the dropping of innumerable grains of corn by their goddess Isis.

The ancient Britons called the Milky Way "Watling Street," Asgard's Bridge, and "the Fairies' Path."

The Chinese and Japanese saw in the Milky Way a celestial river twining across the sky. To the Eskimos it was "the Path of White Ashes." It has also been known as "the Neck of the Sky," "the Path of the Snake," and "the Path of Noah's Ark."

The folk lore of the Milky Way is of fascinating interest, and the reader is urged to extend his knowledge of the subject, referring to the volumes devoted solely to the legends of the stars.

THE SMALL TELESCOPE

There are many facts regarding the manipulation and use of a small telescope concerning which the average amateur is unaware; for at the outset he is liable to meet with difficulties, and the information he requires is not available. The very simplicity of many of these directions regarding the use of the small telescope, seems to have precluded their general publication in books on Astronomy, and yet they are of paramount importance to the beginner.

The purpose of this article, therefore, is to acquaint the amateur with many of the essential facts relating to the small telescope, and aid him in the intelligent use of his instrument.

Telescopes are of two kinds, Refracting and Reflecting. They are rated as of a designated inch of aperture, which means the measure of the clear diameter of the object glass or lense which is nearest to the object observed, or, in the case of a reflector, the clear diameter of the mirror.

The larger the aperture the more powerful the instrument. Thus, the largest refractor is the 40-inch glass at the Yerkes Observatory, the largest reflector the 100-inch at the Mt. Wilson Observatory.

The power of a telescope increases in propor-

tion to the square of the diameter of the objective. A 3-inch glass is more than twice as powerful as a 2-inch, and a 4-inch nearly twice as effective as a 3-inch, and four times as powerful as a 2-inch. A 3-inch refractor is an ideal glass for the amateur, and about the smallest that can be used effectively for astronomical work.

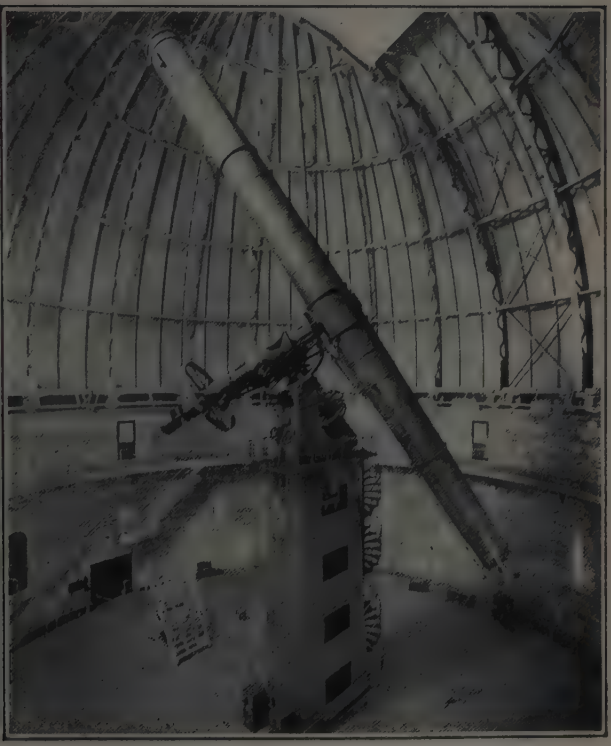
The Refractor

The refracting telescope consists of two convex lenses, the object glass, or objective, which forms the image of the object observed, and the eyepiece, or ocular, which is the lense nearest to the eye in the tube, and which magnifies the image formed by the object glass.

The object glass is the important part of the telescope, and should be treated with great care. This lense in good telescopes is "achromatic," which means that it is composed of two or three lenses made of glass of different density, and so proportioned as to eliminate the false colors which appear in a single lense.

The Reflector

In this type of telescope, a parabolic mirror takes the place of the objective in the refractor. The mirror is placed at the lower end of the tube. The light rays from an object pass down the tube, and are reflected back up the tube where they are intercepted by a small plane



THE YERKES 40-INCH REFRACTOR

The largest refracting telescope in the world. Its big lens weighs 1,000 pounds, and its mammoth tube, which is 62 feet long, weighs about 12,000 pounds. The parts to be moved weigh approximately 22 tons.

The great 100-inch reflector of the Hooker telescope at Mt. Wilson—the largest reflecting instrument in the world—weighs nearly 9,000 pounds and the moving parts of the telescope weigh about 100 tons. It collects over six times as much light as the Yerkes, and 250,000 times as much as the naked eye.

The new 72-inch reflector at the Dominion Astrophysical Observatory, near Victoria, B. C., weighs nearly 4,500 pounds, and the moving parts about 35 tons.

mirror or "flat," and reflected at right angles through the side of the upper end of the tube, where the eyepiece is located. A person observing a star with a reflector gazes horizontally at the image formed by the vertical rays of light passing down the tube. The foregoing refers to the Newtonian form of reflectors.

In the Gregorian form, which shows erect images, the light rays are reflected back by a small concave mirror through a hole in the center of the large mirror to the ocular.

The Cassegranian type of reflector is similar to the Gregorian except that the rays are reflected to the eyepiece by a convex mirror. In both the refracting telescope and the Newtonian and Cassegranian types of reflectors an inverted image is shown in the field of the eyepiece.

Eyepieces

Eyepieces, or oculars, usually consist of two lenses mounted in a short brass tube, which is

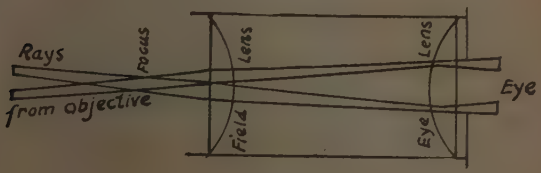


Fig. 1

either screwed on to the adapter, a short tube that projects from the lower end of the refracting telescope, or simply slipped into place.

Eyepieces, generally speaking, are of two types, positive and negative. In the positive eyepiece, Figure 1 (on the preceding page), the focus point of the objective is outside the eyepiece, and this type gives a flatter field than the negative eyepiece. The positive eyepiece can be used as a magnifier, and is in fact a small microscope. The negative eyepiece cannot be put to such use. In the negative eyepiece, the focus point lies between the lenses. See Figure 2.

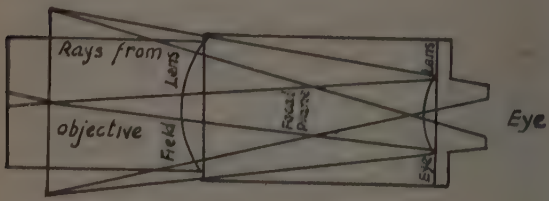


FIG. 2

Telescopes are generally provided with a terrestrial eyepiece, a long tube to accommodate several lenses to erect the image. This eyepiece should not be used in observing celestial objects, as the additional lenses cut down the light received by the eye and this is a great handicap in observing the stars.

To Find the Power of an Eyepiece

Magnification depends on the ratio between the focal length of the objective and that of the eyepiece. To figure the magnification divide the

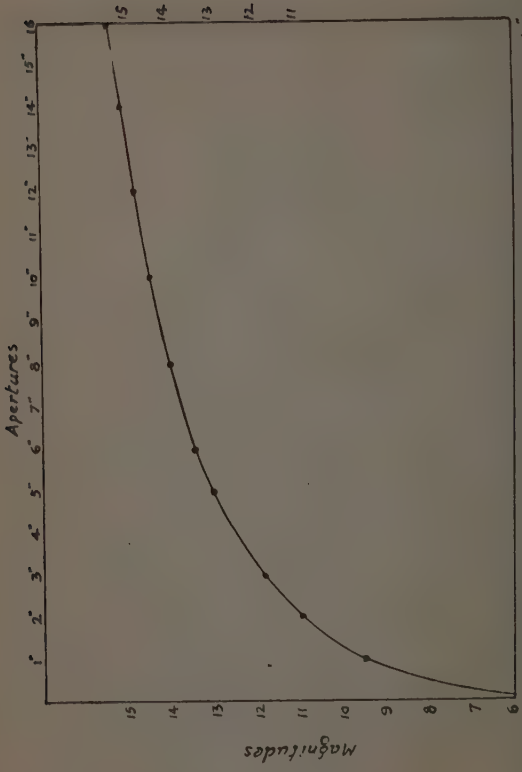
focal length of the objective by the focal length of the eyepiece. Thus: objective focal length 36 inches, eyepiece focal length ½ inch, gives magnification of 72 diameters, and the eyepiece is called 72 power.

Observers should have at least three eyepieces in addition to a terrestrial eyepiece. A low power of ten times to the inch of aperture for coarse star clusters, comets, nebulæ, and Variable Stars; a medium power of thirty times the inch of aperture for the Moon, Planets, and Double Stars; and a high power of sixty times the inch of aperture to use when the "seeing" is good, that is, when the air is dry and quiescent, for viewing the Planets, and close Double Stars, and faint Variable Stars.

The theoretical limit of magnification is 100 diameters to the inch of aperture, but in practice 50 diameters is about the limit of use. The Diagram (p. 438) shows the curve of stellar minimum visible in telescopes up to 16 inches in aperture. Thus it appears that a 13th magnitude star is the faintest star visible in a 5-inch telescope.

Set up a carefully divided scale, with equal divisions, some distance away. With both eyes open view the scale with the naked eye, and with the telescope. The number of divisions on the scale covered by the magnified image of one of them equals the power of the eyepiece used.

It is important to know the diameter of the field of the eyepiece. To obtain this, observe a star near the celestial Equator, say δ Orionis, or ζ Aquarii. Note the time it takes for the star to pass directly across the field. Multiply



Curve showing the faintest stars visible theoretically for telescopic Apertures 1"-16"

the time by 15, and this will give the diameter of the field in minutes and seconds of arc.

To test the telescope, use the highest power ocular on a good night for observing when there is no marked scintillation of the stars. If the glass is a good one a star should appear as a sharp absolutely round disk of light surrounded by one or two concentric rings of light. These rings are called "Diffraction Rings," and the disk is a spurious disk, as the stars are too far away for us to see their actual disk.

Polaris is probably the best star to use in the initial telescopic tests, as it remains stationary and has a faint companion. The first test is to observe whether the central spurious disk is absolutely round or not. Then observe the appearance of the disk when it is in or out of focus. If the spherical aberration is incorrect the outer rim of the star disk will be brighter than the center when the eyepiece is pushed in, and out of focus; the center will appear brighter when the eyepiece is drawn out and out of focus. If the curves of the objective are not even the disk will appear oval in one or the other of the out of focus positions. If there are veins in the objective, wings or notches will be seen in the disk.

Bad images may be caused by scratches on the surface of the objective, or the objective may not be set at an exact right angle to the axis of the tube, or the eyepiece itself may be at fault.

A 3-inch telescope with a 60-power ocular should make this page legible at a distance of

240 feet, or four feet for each unit of power. A perfect telescope should separate a double star consisting of two sixth magnitude stars, whose distance from center to center in seconds of arc is equal to 4.56 divided by the inches of aperture, that is, a 3-inch glass should just divide a double star whose distance is 1.5″.

The Use of the Telescope

Let us assume that you have purchased a three-inch refracting telescope of standard make, as it should be, for the reason that you are never sure of an inferior glass, and a poor telescope is practically worthless. The glass is generally furnished with a simple tripod, and the whole outfit usually comes neatly boxed with a set of eyepieces.

The setting up of the tripod should not bother anyone. A word as to the mounting, or tripod head in this case. We will assume that yours is what is known as the Alt-Azimuth type, that permits of two motions, up and down, the altitude part, and from right to left (or vice versa), the motion in azimuth.

This is the simplest form of telescopic mounting and quite adequate for the purposes of the amateur. We will not discuss the Equatorial mounting, which is the type of mounting of all the great telescopes, and the preferable mounting for all telescopes larger than a 4-inch glass. As a rule when a man has used a small instrument for a time he wants a larger one. By that time he knows considerable about the subject of in-

struments and mountings, knows what he wants, and where he can obtain information for adjusting the instrument. Few amateurs at the outset have sufficient knowledge concerning telescopes and their use to warrant purchasing a large equatorially mounted telescope.

We have set up the glass, removed the cap from the objective, and attached the low power eyepiece. You can roughly tell the power of the eyepieces by examining the smaller of the two lenses, the one that is nearest to the eye. You will note that these lenses in the different eyepieces vary in diameter. The low power is the lense with the largest diameter. The lense smallest in diameter is the high power.

Before beginning to observe you should see whether the glass is equipped with a dew cap, that is, a cylindrical projection beyond the objective to protect it from being fogged by the dew. It may be that one is attached and only needs to be pulled out to the proper length. If there is no such device, you should make a dew cap by rolling a sheet of cardboard or blotting paper the diameter of the tube and strapping it on, allowing it to project about ten inches beyond the objective.

You should set up the telescope in a place where there is no artificial light visible, and where you are protected from the wind. Artificial light in the eye should be avoided in all telescopic work, and any vibration of the tripod renders good definition impossible. If you cannot avoid the wind, construct a light portable shield to protect you while observing.

You should have a red light handy for consulting your book and making notes. You can either use a bull's eye lantern with a red shade or a hand flashlight with red tissue paper attached to the bulb with a rubber band. The latter is most satisfactory. You will find that the red light does not dazzle the eye, and that you do not have to wait for the eye to become accustomed to the darkness as you do if you use a white light.

Let us assume that your low power eyepiece is 30 power. This means that when you view the Moon, which is 240,000 miles away, you are viewing it at a distance of 8000 miles. It is simply a matter of dividing the distance from an object by the power of the ocular to discover how magnification decreases distance. In observing the stars even with our largest telescopes magnification is a matter of no consequence as stellar distances are so tremendous.

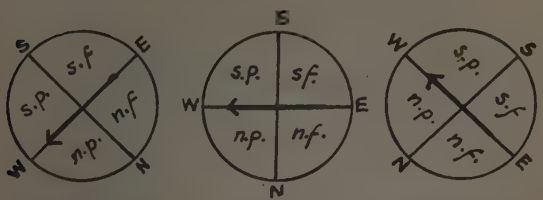
The inversion of the field is a matter to bear in mind, especially the orientation. The diagram indicates the field of the telescope properly oriented. It is, of course, a matter of no consequence if the celestial objects are inverted, we simply have to bear in mind the fact of the change in the position of the cardinal points of the compass. (See diagram on opposite page.)

The telescopic view of a star is a mere point of light, a spurious disk it is called, and around it (if your glass is a good one) you should see the diffraction rings.

You are now ready to observe. Point the glass at a bright star. It is not as easy as you

might think to pick up a star at once for the field of view is very small, but with a little practice you will be able to direct the glass at once to any object.

Observe with either eye, keeping the other open or closed as you prefer. If you are accustomed to wear glasses take them off when observing with the telescope. Use the focusing screw on the side of the tube to get sharp definition, putting the glass in and out of focus until you find the spot where the image is sharp.



Star East, rising Star South Star West, setting

n.p. north preceding.
n.f. north following.
s.p. south preceding.
s.f. south following.

Arrow indicates direction of star's motion across the field.

As you are observing the star you will note that it appears to move across the field, and you will have to keep moving the glass to bring it back into the field. This movement of the star always astonishes those who use a telescope for the first time. It is entirely due to the fact that you are magnifying the Earth's motion, and it is the telescope that is moving and not the star.

Large telescopes are equipped with slow motions and clockwork to counteract this motion and keep the object observed in the field continually. Clockwork is essential for all photographic work that is done on celestial objects.

It is presumed that you know the constellations and the names of the bright stars, otherwise you will not know what you are looking at. To fully enjoy telescopic work this knowledge is essential.

The Moon is the most satisfactory of all celestial objects to view in a telescope, because of its comparative proximity, and in lunar observations you have a mine of enjoyment in locating the various features of interest on the surface of our satellite. It is amazing how much lunar detail a three-inch glass will reveal. The best time to view the Moon is at first quarter for then you see the details along the terminator, the line of demarcation between sunlight and darkness. The full moon is always a disappointing sight as lunar detail is revealed chiefly by shadows. The light dazzles the eye and there is no contrast of color to reveal details. The amateur should secure a good map of the Moon and identify the many rare objects of interest that even a small glass reveals.

Lunar occultations are of particular interest. Consult the *Nautical Almanac* for the necessary data. See chapter on lunar occultations.

The planets furnish a field of interesting telescopic work. You can see the rings of Saturn, and one or two of its brightest moons, four of Jupiter's satellites, and view the interesting

phenomena they are constantly presenting. The belts of Jupiter are also visible.

The planets Venus and Mercury can be seen in crescent phase, and you can see the polar caps on the planet Mars. It is also interesting to endeavor to locate the planets Uranus and Neptune. The former can be seen in a field glass if you know its exact position, but Neptune is a difficult object to locate unless you have an equatorial.

A Star Atlas is an absolute necessity. Schurig's is satisfactory and contains a map of the Moon. The atlas shows you the position of many star clusters, and enables you to plot the position of a comet or nova should one appear.

Double stars furnish a wide field of interest, but the most beautiful sights in the telescope are the coarse star clusters. Do not expect too much of your high power ocular, as a great deal depends on the quality of the "seeing," and good seeing is a rarity.

You may wish to view the sun spots, which are always interesting objects to observe. NEVER look directly at the sun through the telescope. If you do there is great danger of losing your eyesight. Use a solar eyepiece, but better yet project the image of the Sun on a piece of white cardboard held a short distance from the ocular in the focus. You can arrange a frame to attach to the tube of the telescope to hold the cardboard; this, when properly shaded, makes an admirable arrangement.

The most practical telescopic work the amateur can engage in is Variable Star observing.

This is fascinating work, involves no mathematics, and the details are easily mastered. A three-inch telescope is entirely adequate for the purpose, and all observations of Variable Stars are of scientific value. W. T. Olcott, whose address is Norwich, Conn., will be glad to furnish further information on the subject.

The questions are often asked: What is the best type of telescope for the amateur? What advantage has the refractor over the reflector, if any. Many amateurs have made their own reflectors and find them most satisfactory. The reflector has this advantage over the refractor in that it always permits the observer to assume a comfortable observing position, and it is less expensive.

Reflectors, on the contrary, are clumsier instruments than refractors, and are not as portable, but the chief difference between the two types lies in the mirror of the reflector which has to be resilvered every few months. Those who are familiar with the process of resilvering do not regard this as a troublesome matter, but the average amateur who knows nothing about telescopes finds the technique of resilvering difficult to master, and regards it as more or less of a nuisance. The refractor is always in order and ready for business.

Professionals find a good use for both types of telescopes. The refractor defines better, has a larger field of good definition, and is more convenient to use than the reflector. Refractors are used almost exclusively in visual observations and measures.

Reflectors excel in all photographic work, and in the observation of faint comets, and nebulæ, and they are better than refractors for spectroscopic work.

For the simple needs of the average amateur a three-inch refractor, with Alt-Azimuth mounting, is ideal for his purposes. It is easily taken in and out of the house, can be boxed and carried about, and reveals hundreds of celestial objects of interest to contemplate with enjoyment or to study scientifically.

In closing this brief article designed to assist the telescopist it is well to remember that the true observer is above all things an amateur, using the word in that splendid sense to which Professor Hale has introduced us:

"The amateur is the man who works on Astronomy because he cannot help it, because he would rather do such work than anything else in the world, and who therefore cares little for hampering traditions, or for difficulties of any kind."

Hints for Telescopists

Do not observe with a telescope from a warm room by pointing the glass through the open window. The currents of warm air seeking an outlet distort the image of any object observed.

Do not try to observe through a pane of window glass. Take the glass out of doors and set it up in a dark, sheltered spot.

Treat the objective with great care. It should be kept capped when not in use. If dirt collects

on it, first dust off the lens with a soft camel's hair brush. If it needs further cleaning rub it lightly with a soft piece of cloth or chamois that has been kept in a dust free receptacle. Better yet get from an optician the Japanese paper used for cleaning lenses.

Never touch the lens with your hand and do not wipe the lens when it is damp. If the lens becomes dewed take the glass in a warm room and let the lens dry off.

It is well to set up the glass in the open air a short time before it is used to allow the lens to cool to the temperature of the outdoor air.

The quality of the "seeing" differs greatly from night to night. The marked scintillation of the stars indicates unsatisfactory conditions for observing. Many objects are best viewed in moonlight or when there is a slight haze.

In observing faint objects, close the observing eye for a few moments, and open it at the eyepiece. In searching for faint double stars make a mental note of the distance and position angle. If you do not see a faint companion star try the method of averted vision, that is, gaze intently at another part of the field, and the more sensitive portion of the retina will often reveal it.

It is well to have a small table near at hand to hold your lamp, star atlas and note book. Use a straight backed chair and to get the best results, always assume a comfortable position in observing.

Make careful notes of all observations, stating the date, time, seeing conditions and aperture

of glass. If you discover a comet or a nova, that is, a new star, plot its position on your star atlas, and telephone or telegraph the information to the nearest Observatory. By so doing you may achieve the fame of the discovery.

Do not observe objects near the horizon where the earth's atmosphere renders good seeing impossible. The best views are obtained of objects near the zenith. For observing objects in the zenith you should have a diagonal eyepiece which permits you to observe at right angles to the axis of the tube in a comfortable position.

You will find the low power eyepiece the most satisfactory, on the whole, for general use. Should you get an exceptionally fine night for observing make the most of it by testing out your glass with the high power eyepiece.

Lastly, remember that the telescope is a scientific instrument. Take good care of it and it will never cease to offer you many hours of keen enjoyment, and a source of pleasure in the contemplation of the beauties of the firmament that will enrich and ennoble your life.

CHRONOLOGY

The science of Astronomy is without doubt the oldest of the true sciences. Its early history, like that of most histories, is lost in the depths of time, but the records of the ancients carry it dimly to about five thousand years ago. These records, moreover, are such that they demonstrate a close study for centuries previous.

Unquestionably the rising and setting of the Sun and the Moon, and the phases of the latter, the most evident of celestial phenomena, must have caused a wonderment and thought at the very dawn of human intelligence. From that first wonderment to the first astronomical records is a time measured only by conjecture.

The earliest records known are those of the Chinese. Then come those of the Babylonians and the Egyptians. It is interesting to note that from some of the Babylonian observations, inscribed upon baked bricks lately excavated, it has been possible to obtain values of some of the Moon's motions accurate enough to be of real assistance in a recent revision of certain lunar tables.

Not till the time of the later Greek philosophers, however, do we get connected data. It was among the last mentioned that real observational astronomy began. That the Greek

nature philosophers devoted much thought to the structure of the Universe is shown by the fact that we can pick from their theories enough of what we now know to be true to give a fairly accurate description not only of the Solar System but the Universe at large. Copernicus, who hundreds of years later evolved the true *basic* plan of the Solar System, credits not himself, as the originator of the theory, but Pythagoras (B.C. 569–470).

Unfortunately for the progress of the science, these early philosophers propounded, with their average one true theory apiece, so many absurd conceptions that the conservative thinkers chose to remain supporters of a theory confirmed, or apparently confirmed, by what they themselves saw. It is for this reason that, though great strides were made in observational work, a marvelously ingenious, complicated, and sadly false theory of the system of the Universe was accepted, and held sway for centuries, being superseded only by the present so-called Copernican Theory after the great Kepler had "smoothed out the wrinkles" in this latter.

Through the Middle Ages, the false theory, evolved by Ptolemy, was believed in so tenaciously that the world at large refused to accept the true facts when they were presented. The removal of the Earth from the center of the Universe to the insignificant position of an attendant upon a body supposedly created merely to give light and heat to the Earth was too much for humanity to admit. Indeed, much was done to stamp out this new belittling doc-

trine. History sadly points to Galileo as an old man denying, under threat of torture, the cosmic system he knew to be true, and even more sadly to Bruno, previously burned at the stake for refusing to abandon such heretical beliefs.

From then on, however, the path of Astronomy has been broad and clearly illuminated, Kepler and the mighty Newton being responsible, so to speak, for switching on the lights. It is upon Kepler's demonstration of the true motions of the planetary bodies (and would it were possible to devote many pages here to this most amazing astronomical achievement) and Newton's mathematical demonstration of the *universal rule* of that Gravitation, known since early times, that modern Astronomy stands.

Previous to the time of Galileo, astronomical instruments were of the most primitive and crude construction, and were, in consequence, of feeble assistance. After the invention of the telescope, and its improvement by Galileo, these instruments have evolved with marvelous speed, until now, with the amazingly accurate measuring attachments to the telescope; that greatest wonder of all the ages, the spectroscope, the analyzer of light; and the photographic plate, that magic recorder of the faintest impression of light; and latest, the interferometer, it seems that we have reached the limit of the science of optics. However, that some still more marvelous invention will appear seems, from analogy, to be almost certain. Many times before has Man been at the apparent limit of his abilities, only to step boldly and successfully beyond.

Directly following is a chronology of the main events of Astronomy. For the first part it is necessarily general and broad; but from the time of Copernicus to the present, it is given according to the accepted historical dates.

CHRONOLOGICAL TABLE

Previous to the 5th Century B.C.

A few ancient records have come down to us, which demonstrate the fact that even in those remote years astronomy was by no means a new science.

There are reports of celestial spheres made in China in the 29th century B.C. and another in the 23d century B.C.

It is said that in 2513 B.C. the Emperor Chueni of China recorded a conjunction of five planets, and that Yao gave instructions to his astronomers to determine the positions of the Equinoxes and the Solstices; also that, at this time, the calendar year was of 365 days with an added day every four years, as in our present calendar.

In 2159 (?) B.C. two Chinese Royal Astronomers were put to death for neglecting to predict an eclipse.

Records have been found of comets and eclipses running back to 1640 B.C.

The Saros or eclipse cycle used by the Egyptians and Chaldeans.

Thales (639–546 B.C.), the Greek nature philosopher, explains the phases of the Moon, and measures the angular diameter of the Sun.

Parmenides shortly afterward declares the Earth to be a sphere.

5th Century B.C.

Pythagoras (569–470 B.C.) deduces the theory of planetary motions, which Copernicus later revised.

	Meton (432 B.C.) introduces calendar reform. The Metonic cycle is still used to determine the date of Easter.
	Democritus (470–? B.C.) evolves true general conception of the Universe.
	Heraclitus supposes Earth to rotate upon axis.
4th Century B.C.	Callipus (330 B.C.) corrects eclipse cycle.
	Aristarchus (320–250 B.C.) measures distance of the Sun.
2d Century B.C.	Eratosthenes (276–196 B.C.) measures Earth and inclination of the axis to the ecliptic.
	Aristillus and Timocharis fix positions of zodiacal stars.
	Hipparchus (190–120 B.C.) founds real observational astronomy; again measures inclination of axis; remeasures length of year; computes lunar tables; observes first recorded "new star"; makes first great star charts discovers precession of equinoxes; invents trigonometry.
2d Century A.D.	Ptolemy (139–161) formulates his theory of celestial motions.
7th Century	Alexandrian library burned by Caliph Omar.
10th Century	Moon's variation noted by Abul Wefa.
15th Century	Ulugh-Begh makes first star catalogue since that of Hipparchus.
1473	Copernicus born.
1480	Astrolabe invented by Behaim.
1543	Copernicus publishes *De Revolutionibus Orbium Celestium*, his great work, recalling as a basis the theory of Pythagoras, thus beginning the great advance made by astronomy in the last five hundred years.
	Copernicus dies.
1546	Tycho Brahe born. The most diligent and accurate observer since Hipparchus. He invented and made many instruments, necessarily crude, with which, however, he

did marvelously accurate work. On his observations were founded Kepler's laws.

Galileo born. 1564

Johann Kepler born. He assisted Tycho for several years, and inherited his post at the death of the latter. 1571

Tycho observes a "new star," the first recorded since the time of Hipparchus. This stimulates him to make a star catalogue of great accuracy. In making this he uses corrections of his own for atmospheric refraction. 1572

Galileo discovers isochronism of pendulum. 1583

Bruno burned at the stake. 1600

Tycho dies. 1601

Brilliant "new star" observed by Kepler. 1605

First telescopes made in Holland. 1608 (?)

Galileo improves telescope. 1609

Kepler publishes his work *Astronomia Nova*, including the first two of his great laws of planetary motion.

Four larger satellites of Jupiter, sun-spots, surface irregularities of the Moon, phases of Venus, discovered by Galileo with his telescope. Saturn's rings also first seen by Galileo, but believed to be illusionary. 1610

John Napier publishes his invention of logarithms. 1614

Kepler evolves his Third Law. 1616

Kepler dies. 1630

Transit of Venus foretold by Horrocks. 1639

Galileo dies. 1642

Sir Isaac Newton born.

First serious selenographic work done by Langrenus. 1645

John Flamsteed born. First Astronomer Royal. Maker of the first trustworthy catalogue of stars. 1646

Riccioli discovers first telescopic double star Mirzar.

1655	Huyghens discovers Titan, satellite vi. of Saturn; the largest and first to be seen.
1656	Huyghens describes in cipher the rings of Saturn.
	Edmund Halley, Second Astronomer Royal, born.
1657	First pendulum clock made by Huyghens.
1659	Huyghens translates cipher on Saturn rings.
1660 (?)	Newton experiments with prism and dispersion of light.
1663	Reflecting telescope first proposed by Gregory.
1665	Cassini notes great spot on Jupiter.
	Cassini establishes rotation periods of Jupiter.
1666	Newton makes first reflecting telescope.
	Newton establishes fact that sunlight is a blend of colors which a prism will disperse; the foundation of the spectroscope.
1667	National Observatory at Paris founded.
	Telescope first used as pointer by Picard.
1671	Cassini discovers Japetus, satellite viii. of Saturn.
1672	Cassini discovers Rhea, satellite v. of Saturn.
1675	Cassini discovers division in Saturn's ring.
	Time required by light to travel discovered and measured by Roemer.
1676	Royal Observatory at Greenwich founded.
1681	First transit instrument built by Roemer.
1684	Cassini discovers Tethys and Dione, satellites iii. and iv. of Saturn.
1687	Newton publishes his *Principia*, containing his exposition of the universal rule of the law of gravitation.
1691	Oval form of Jupiter observed by Cassini.
1692	Cassini makes chart of Moon.
1705	Halley first predicts return of a comet, the one now bearing his name.

Solar prominences first noted.	1706
Miraldi notes variation in brilliancy of Jupiter's fourth satellite.	1707–1713
Halley detects motions of Arcturus and Sirius.	1718
Halley appointed the second Astronomer Royal.	1721
Newton dies.	1727
Bradley publishes his discovery of the aberration of light.	1729
Herschel born.	1738
Halley dies.	1742
Heliometer invented by Savary.	1743
Bradley discovers that the inclination of the Earth's axis is not constant (*nutation*).	1748
Achromatic lens invented by Dollond.	1757
Halley's Comet upon first predicted return, first observed by Palitsch.	1758
Maskelyne, Astronomer Royal, lays foundation of Nautical Almanac.	1767
Bode's "Law" discovered.	1772
Herschel establishes rotation of Saturn.	1775–94
Herschel discovers Uranus.	1781
Herschel appointed Astronomer to George III.	1782
Goodricke advances correct theory, explaining variability of Algol.	1783
Laplace published elements of Uranus.	
Herschel deduces motion of Sun through space.	
Herschel discovers two satellites of Uranus.	1787
Herschel's great reflector finished.	1789
Herschel discovers Mimas and Enceladus, satellites i. and ii. of Saturn.	
Large disks of flint-glass successfully made by Guinand.	1790 (?)
Laplace publishes *Système des Mondes*, containing his theories on the Nebular Hypothesis.	1796
Piazzi discovers first planetoid (Ceres).	1801

	De Zach rediscovers the lost first planetoid.
1802	Olbers discovers second planetoid (Pallas).
1803–04	Herschel discovers revolution of binary stars.
1804	Harding discovers third planetoid (Juno).
1807	Olbers discovers fourth planetoid (Vesta).
1815	Fraunhofer first measures lines in solar spectrum.
1822	Herschel dies.
	Stower measures diameter of Jupiter's largest four satellites.
1833	Vast meteoric shower in America.
1836	Hopkins Observatory, Williams College, founded; oldest in America.
1837	Chart of Moon made by Beer and Maedler.
1837–1840	Bessel first successfully measures stellar parallax.
1838	Sun-spot periodicity discovered by Schwabe.
1839	Pulkowa Observatory completed.
	Harvard College Observatory founded.
1840	Canals on Mars first indicated in drawings by Beer and Maedler.
1842	Doppler evolves method of measuring velocity in line of sight of luminous body.
1843	Schwabe announces Sun-spot periodicity.
1844	Bessel pronounces Sirius and Procyon binary systems with dark or very faint companions.
1845	First photograph of Sun taken; a daguerreotype by Foucault and Figeau.
	Fifth planetoid discovered.
	Lord Rosse's great 6 ft. reflector built.
	Adams completes calculations of Neptune's position.
1846	Le Verrier completes computation of position of Neptune.
	Neptune found by Galle.
	Satellite of Neptune discovered by Lassell.
	Biela's comet observed to split.
1848	Hyperion, satellite vii. of Saturn, discovered simultaneously by Bond and Lassell.

Bond successfully photographs Moon. 1850

Solar prominences proved appendages of the Sun not Moon. 1851–1860

Lamont connects variation of compass with sun-spot period. 1851

Lassell discovers two more satellites of Uranus.

Foucault "pendulum-experiment" proving rotation of Earth.

"Magnetic Storms" found to be periodic. 1852

De la Rue first uses collodion process in astronomical photography. 1853

De la Rue first uses stereoscope.

Second return, after prediction, of Halley's Comet. 1854

De la Rue constructs first photoheliograph. 1857

Bond first photographs double star Mirzar.

Donati's Comet. 1858

Reversal of spectrum lines experimentally explained by Kirchoff. 1859

Clark discovers companion to Sirius. 1862

Velocity of light found experimentally by Fizeau and Foucault independently.

Rotation of Mars deduced by Kaiser.

Carrington establishes the unequal rotation of the solar surface. 1863

Nebulæ first studied by spectroscope. 1864

Donati first observes spectrum of comet.

Spectrum of nebula first observed by Huggins.

Spectrum of sun-spot compared with that of solar surface by Lockyer. 1866

Return of Leonid meteorites.

Le Verrier computes elements of Leonids. 1867

Helium found in the Sun. 1868

Huggins measures velocities of stars in line of sight.

Spectroscope first used in eclipse of Sun. Solar prominences viewed by Jansen for first time without eclipse.

1869	Dawes makes first good map of Mars.
1876	Gelatine dry plates first used in astronomical photography, by Huggins.
1877	Schiaparelli first maps Martian "Canals."
	Satellites of Mars discovered by Hall.
	Leverrier dies never having observed Neptune.
1877–89	Gill more correctly ascertains distance of Sun by improved heliometer.
1878	Jupiter's "Great Red Spot" first observed.
1881	Sir W. M. H. Christie, Eighth Astronomer Royal, takes up duties.
1882	Gill makes first comet photograph, and originates stellar chart-photography.
1887	Great photographic star map started by E. C. Pickering.
1888	Lick Observatory completed.
1889	Vogel observes orbital motion of Algol by means of spectroscope.
	Pickering detects first spectroscopic binary, Mirzar.
1890	Schiaparelli announces rotation periods of Venus and Mercury.
1892	Dr. Anderson discovers "Nova Aurigæ."
	Barnard discovers Jupiter's fifth satellite.
1894	Sun-spots proved not always depressions, by Howlett.
	Lowell Observatory founded.
1895	Constitution of Saturn's rings proved by spectroscope (Keeler).
	Helium isolated on the earth.
	X-Rays discovered by Roentgen.
1896	Companion to Procyon discovered by Schaeberle.
1897	Yerkes Observatory opened.
1898	Pickering discovers, by photography, Phœbe, satellite ix. of Saturn.
	Eros, the nearest planetoid, discovered by Witte.
1901	Dr. Anderson discovers "Nova Persei."

Sun photography improved by Hale and Deslandres independently. 1903

Mt. Wilson Solar Observatory founded. 1904

Jupiter's sixth and seventh satellites discovered by photography at the Lick Observatory. 1905

Pickering discovers, by photography, Themis, satellite x. of Saturn.

Einstein announces special theory of relativity.

Lampland of the Lowell Observatory improves plates for spectroscope work. 1907

Slipher of the Lowell Observatory successfully photographs Martian Canals.

Eighth satellite of Jupiter discovered by Melotte. 1908

W. H. Pickering announces the probability of a trans-Neptunian planet. 1909

The photoheliometer invented by Poor.

Campbell announces that his investigations showed an inappreciable amount of water vapor on the planet Mars.

Third (since prediction) return of Halley's comet. On night of May 18th the earth passes through the plane of its orbit. 1910

The following noted astronomers died during the year: Sir William Huggins, G. V. Schiaparelli, J. G. Galle.

Greenwich time adopted in France. 1911

Dr. Gonnessiat rediscovers Encke's comet.

Total eclipse of the sun April 28th.

Proxima Centauri discovered by Innes.

American Association of Variable Star Observers founded.

A spectroscopic determination of the period of rotation of the planet Venus made by M. Belopolsky. It was found to be about one day. 1912

Two novæ discovered in Gemini.

The 30″ refractor of the Allegheny Observatory completed.

1913 Kohlschütter develops method of determining absolute magnitudes of stars from their spectra.

1914 Variability of two of Saturn's satellites discovered at Lowell Observatory.

The presence of a general magnetic field in the sun confirmed at Mt. Wilson.

1915 Ninth satellite of Jupiter discovered by Nicholson of the Lick Observatory, from plates made in 1914.

The Crepe ring of Saturn measured at the Lowell Observatory.

Return of Winnecke's comet.

Einstein announces general Theory of Relativity.

1916 Dr. Coblentz announces that red stars emit far more radiation than blue stars of the same magnitude.

1916–7 Slipher of Lowell Observatory demonstrates rotation of spiral nebulæ.

Slipher measures radial velocities of nebulæ.

1917 Percival Lowell dies.

E. C. Pickering announces that the light of the planet Uranus is slightly variable.

Barnard discovers his "proper-motion" star.

1918 Nova discovered in the constellation Aquila June 8th.

1919 Total eclipse of the sun May 29th.

Displacements of stellar images claimed as a proof of Relativity Theory.

Two novæ discovered in the Andromedæ nebula.

E. C. Pickering dies.

1920 Abbott announces that the sun is variable.

A new method of photographing extremely faint objects announced by Professor Shapley.

Hale and Pease apply the interferometer to the 100″ reflector at Mt. Wilson, and make first measurements of the diameter of a star, Betelgeuze.

Approximately 2000 hitherto unknown nebulæ discovered by Donald H. Menzel, Harvard College Observatory Station at Arequipa, Peru. 1922

Total solar eclipse September 21st.

Campbell succeeds in measuring amount of curvature in a ray of light passing through a gravitational field.

A nova in the constellation Cygnus announced by the Astronomer Royal of Great Britain. 1923

E. C. Barnard dies.

C. G. Abbott succeeds in measuring the heat of the stars to the hundred millionth of a degree at Mt. Wilson. 1924

A faint companion star to omicron Ceti discovered.

D. C. Miller succeeds at Mt. Wilson in detecting a definite ether drift; strong evidence that the Einstein theory is not absolutely correct. Adams finds Einstein effect of light retardation strongly confirmed by companion to Sirius. 1925

Conclusion reached that the spiral nebulæ are island universes a million light years, or more, distant.

Discoveries made by Millikan relating to the structure of the atom.

Variable star Mira found to have a diameter of over 250 million miles.

C. E. St. John discovers that the companion of Sirius has about the volume of the planet Uranus.

Nova in Pictoris, the most brilliant in recent years.

Yale University establishes new Observatory in South Africa.

F. H. Seares completes photographic survey of the heavens and concludes that the total number of stars is at least thirty trillion. 1926

1926 Shapley announces that the cluster Messier 61 is ten million light years distant.

Drs. Adams and St. John estimate that the hemisphere of the planet Mars turned toward the earth is as dry as the Sahara desert. The water vapor in the atmosphere is less than 3% that in the clear air of Pasadena, Cal. The temperature ranges between noon and midnight from 75° above zero to 40° below.

R. A. Millikan announces the discovery of a new type penetrating rays which reach the earth from outer space.

Edwin B. Frost announces that helium stars travel only about one-fourth as fast as yellow stars.

1927 It was announced that though the volume of the star Betelgeuze is fifty million times that of the sun, its mass is only fifty times that of the sun.

Stebbins announces that the four bright moons of Jupiter rotate on their axes in the same time that it takes them to revolve around their planet.

Bowen announces that the gaseous nebulæ in the Milky Way are composed of oxygen and nitrogen in an ionized condition, the combination proving to be the long sought for "nebulium."

1928 Adams and Russell succeed by means of a new spectrograph in securing stellar spectra almost as detailed as those of the standard spectra of the sun.

Antares and Betelgeuze found to have an atmosphere perhaps a hundred times as dense as that of the sun.

Shapley announces the location of the center of "the greater Galactic system" in the general direction of the constellation Scorpius 25,000 light years distant.

Nicholson announces finding the element boron in the sun.

Pettit announces a close relationship between the amount of ultra-violet rays in the sun's light and the number of sun spots. 1928

Shapley announces evidence that many if not all of the stars are surrounded by meteors and comets.

Einstein announces his new Field Theory. 1929

Spectra of very distant nebulæ secured by Humason at Mount Wilson indicate either terrific recessional velocities or the effect on light waves of the "curvature of space-time," this effect having been suggested by Hubble.

THE NAMES OF THE STARS AND THEIR MEANINGS

It will be noted that the date of culmination is given in almost every case. By culmination is meant the highest point reached by a heavenly body in its path, at which point it is said to be on the meridian or due south. In this hemisphere this is in each case the highest point north.

For example:—the culmination of the sun occurs at noon.

The time when the stars here mentioned culminate on the dates specified is in each case nine o'clock P.M.

ACUBENS, *α Cancri*, "the claws."
Situated in one of the Crab's claws. It is white in color and culminates March 18th.

A-DAR′-A, *ε Canis Majoris*, "the virgins," a name for four stars, of which Adara is brightest.
Situated in the Dog's right thigh. It is pale orange in color, and culminates Feb. 11th.

ADHIL, *ε Andromedæ*, "the train of a garment."
Situated in the left shoulder of the chained lady.

ALADFAR, *μ Lyræ*, "the talons" (of the falling eagle). (al-ad-fär)

AL BALI, *ε Aquarii*, "the good fortune of the swallower."

AL-BI′-REO, or Al-bir′-ē-o, *β Cygni*, origin doubtful. Means the beak of the hen. Situated in the beak of the Swan and the base of the Cross. Its color is topaz yellow, and it culminates Aug. 28th.

ALCAID, *η Ursæ Majoris*.
See Benetnasch.

ALCHIBA, *α Corvi*, "the tent," the desert title for the constellation. Situated in the eye of the Crow. Orange in color.
(al-kē-bä′)

ALCOR, g *Ursæ Majoris*, "the cavalier" or "the rider."
(al'-kôr) Situated close to Mizar in the handle of the "Dipper." Silver white in color. The Arabs called this star "Saidak," meaning "the proof," because they used it to test a good eye.

AL-CY'-O-NE, η *Tauri*.
Greenish yellow in color. The brightest of the Pleiades. Situated in the neck of the Bull.

AL-DEB'-A-RAN, α *Tauri*, "the hindmost" or the "follower," *i. e.* of the Pleiades.
Situated in the eye of the Bull. Pale rose in color. It is receding from the earth at the rate of thirty miles per second, and culminates Jan. 10th.
α Tauri is sometimes called Palilicium.

ALDERAMIN, α *Cephei* "the right arm." It now marks
(Al-der-am'-in) the shoulder of Cepheus.
White in color. It culminates Sept. 27th.

ALDHAFERA, ζ *Leonis*.
Situated in the "Sickle," and the neck of the Lion. It culminates April 8th.

ALFIRK, or ALPHIRK (al-ferk'), "stars of the flock," β *Cephei*.
The Arab name for the constellation.
Situated in the girdle of Cepheus.
White in color. It culminates Oct. 2d.

ALGEIBA, γ *Leonis*, "the mane."
(al-jē-bā) Situated in the "Sickle," and the shoulder of the Lion. It is approaching the earth at the rate of twenty-four miles per second, and culminates April 9th.

AL'-GE-NIB, γ *Pegasi*, "the wing," possibly the "flank" or "side."
Situated in the wing of the Horse. White in color, and culminates Nov. 14th.

AL′-GE-NIB, *α Persei*, "the side," or Mirfak, "the elbow."
Situated in the right side of Perseus. Lilac in color and approaching the earth at the rate of six miles per second. It culminates Jan. 1st. This star is also called Alchemb.

ALGENUBI, *ε Leonis*, "the head of the Lion."
(al-je-nō′-bi) A yellow star situated in the Lion's mouth.

AL′-GOL, *β Persei*, "the ghoul" or "demon."
Situated in the head of the Medusa held in the Hero's left hand. White in color. It is approaching the earth at the rate of one mile per second, and culminates Dec. 23d.

ALGORAB, or ALGORES, (*δ*) *Corvi*, "the raven."
(al-go-räb′) Situated on the right wing of the Crow. Pale yellow in color. It culminates May 14th.

ALHENA, *γ Geminorum*, "a brand on the right side of the
(al-hen′-a) camel's neck," or a "ring" or "circlet."
Situated in the left foot of Pollux. White in color, and culminates Feb. 8th.
Alhena is sometimes called Almeisam.

AL-I-OTH, *ε Ursæ Majoris*, disputed derivation.
Situated in the tail of the Great Bear. It is approaching the earth at the rate of nineteen miles per second. It culminates May 20th.
Alioth, the name sometimes given to *α* and *θ* Serpentis.

AL-KAID, *See* ALCAID.
(al-kād)

ALKALUROPS, *μ Boötis*, "a herdsman's club, crook, or
(al-ka-lū′-rops) staff."
Situated near the right shoulder of the Herdsman. Its color is flushed white.

ALKES, α *Crateris*, from Al Kas, "the cup," the Arab
(al′-kes) name for the constellation.
Situated in the base of the Cup. Orange in color, and culminates April 20th.

ALMAC, γ *Andromedæ*, "a badger," possibly "the boot."
Situated in the left foot of Andromeda. Orange in color, and culminates Dec. 8th.

AL NAAIM, τ and ν *Pegasi*, "the cross bars over a well."

AL NASL, or ELNASL (el-nas′-l), γ *Sagittarii*, "the point
(al-nas′-l) head of the arrow."
Situated in the arrow's tip. It is yellow in color, and culminates Aug. 4th.
This star sometimes called Nushaba and Warida.

AL NATH, γ *Aurigæ*, and β *Tauri*, "the heel of the rein-
or holder," or the "butter," *i. e.* the "horn."
NATH Situated in the right foot of the Charioteer, and the tip of the northern horn of the Bull. Brilliant white in color, and culminates Dec. 11th.

ALNILAM, ε *Orionis*, "a belt of spheres or pearls."
(al-ni-lam′) Situated in Orion's belt. It is bright white in color, and is receding from the earth at the rate of sixteen miles per second. It culminates Jan. 25th.

ALNITAK, ζ *Orionis*, "the girdle."
(al-ni-tak′) Situated in Orion's belt. Topaz yellow in color. It is receding from the earth at the rate of nine miles per second, and culminates Jan. 26th.

AL-NIYAT, σ *Scorpii*, "the outworks of the heart."
Situated near the Scorpion's heart. It is creamy white in color.

AL′-PHARD, α *Hydræ*, "the solitary one in the serpent."
or Situated in the heart of Hydra. Orange in
(al-fārd′) color, and culminates Mar. 26th. The Chinese call this star "the Red Bird."

AL-PHEC'-CA, α *Coronæ Borealis*, "the bright one of the dish."
See Gemma. Century Dictionary gives meaning "the cup or platter of a dervish."

AL'-PHE-RATZ, α *Andromedæ*, "the head of the woman in
or (al-fe-rats') chains." "The navel of the horse."
Situated in the head of Andromeda. White and purplish in color. It culminates Nov. 10th.
Alpheratz is sometimes called Sirrah.

AL-PHIRK, β *Cephei*, from al-Firk, the flock.

AL RAKIS, μ *Draconis*, "the dancer."
Situated in the Dragon's nose. Brilliant white in color. The Century Dictionary gives for this star Arrakis, "the trotting camel."

AL RESCHA, α *Piscium*, "the cord or knot."
Situated in the knot joining the ribbons that hold the Fishes together. Pale green in color, and culminates Dec. 7th.

ALSAFI σ *Draconis*.

ALSCHAIN, β *Aquilæ*, part of the Arab name for the con-
(al-shān') stellation.
Situated in the head of Antinoüs. Pale orange in color, and culminates Sept. 3d.

AL SHAT, ν *Capricorni*, "the sheep."

AL'-TAIR, or ATAIR, α *Aquilæ*, "the flying eagle," part of the Arab name for the constellation. Situated in the neck of the Eagle. Yellow in color, and culminates Sept. 1st.

ALTERF λ *Leonis*, "the glance," *i. e.* the Lion's eye.
(al-terf') Situated in the Lion's mouth, the point of the Sickle. Red in color.

ALUDRA, *η Canis Majoris*, "the virgins." The four stars
(al-ö′-dra) near each other in Canis Major.
Situated in the Great Dog's tail. Pale red in color, and culminates Feb. 21st.

ALULA BOREALIS, *ν Ursæ Majoris.*
ALULA AUSTRALIS, *ζ* " " The "northern and southern wing."
Situated in the Southern hind foot of the Great Bear. The latter star is sometimes called El Acola.

AL′-YA, *θ Serpentis.*
Situated in the tip of the Serpent's tail. Pale yellow in color. It culminates Aug. 18th.

ANCHA, *θ Aquarii*, "the hip."
Situated in the right hip of Aquarius.

ANT-ĀR-ES, or AN-TA′-REZ, *α Scorpii*, "the rival of Mars."
Situated in the heart of the Scorpion. Fiery red and emerald green in color. It culminates July 11th.

ARC-TŪ-RUS, *α Boötis*, "the leg of the lance-bearer," or "the bear-keeper."
Situated in the left knee of the Herdsman. Golden yellow in color. It culminates June 8th.

ARIDED, *See* DENEB.

ARNEB, *α Leporis*, "the hare," the Arab name for the con-
(ār′-neb) stellation.
Situated in the heart of the Hare. Pale yellow in color. It culminates Jan. 24th.
α Leporis is sometimes called Arsh.

ARKAB, *β Sagittarii*, "the tendon uniting the calf of the
(ār′-kab) leg to the heel."
Situated in the Archer's left fore leg.

ASHFAR, *μ* and *ε Leonis*, "the eyebrows."
Situated close to the Lion's right eye. *μ* orange in color, sometimes called Alshemali or Asmidiske.

ASPIDISKI or ASMIDISKE, *ι Argus*, "in the gunwale."
(as-pi-dis'ke) Situated in the shield which ornaments the vessel's stern. Pale yellow in color.
The Century Dictionary gives "a little shield" as the meaning for this star name.

ASCELLA, *ζ Sagittarii*, "the armpit."
Situated near the Archer's left armpit. It culminates Aug. 19th.

ASCELLUS, *θ Boötis*.
It marks the finger tips of the Herdsman's upraised hand.

ASCELLUS BOREALIS, *ν Cancri*, "northern ass."
Straw color.

ASCELLUS AUSTRALIS, *δ Cancri*, "the southern ass."
Situated on the back of the Crab. Straw color.

ATIK, *ο Persei*.
Situated in the wing on the right foot of Perseus.

AZELFAFAGE, *π Cygni*, "the horse's foot or track."

AZHA, *η Eridani*, "the ostrich's nest."
Pale yellow in color.

BAHAM, *θ Pegasi*, "the young of domestic animals."
Situated near the left eye of Pegasus.

BAT'EN KAITOS, *ζ Ceti*, "the whale's belly."
A topaz-yellow colored star, which culminates Dec. 5th.

BEID (bā'-id), *ο Eridani*, "the egg."
A very white star.

BEL'-LA-TRIX, *γ Orionis*, "the female warrior." The Amazon star
Situated in the left shoulder of Orion. Pale yellow in color. It is receding from the earth at the rate of six miles per second, and culminates Jan. 22d.
The Century Dictionary gives the color as very white.

BE-NET'-NASCH, *η Ursæ Majoris*, "the chief or governor of the mourners" (alluding to the fancied bier). Situated in the tip of the Great Bear's tail. Brilliant white in color. It is approaching the earth at the rate of sixteen miles per second, and culminates June 2d. This star is also called Alkaid, from al-kaid, "the Governor."

BETELGEUZE (Bet-el-gerz'), *α Orionis*, "the giant's shoulder," or "the armpit of the central one." Situated in the right shoulder of Orion. Orange in color. It is receding from the earth at the rate of thirteen miles per second, and culminates Jan. 29th. Sometimes called Mirzam, the roarer.

BOTEIN, *δ Arietis*, "the little belly."
(bō-tē-in')

CA-PEL'-LA, *α Aurigæ*, "the she-goat." Situated in the left shoulder of the Charioteer. It is a white star, and is receding from the earth at the rate of nineteen miles per second. It culminates Jan. 19th. The color of Capella is nearly that of the sun.

CAPH, *β Cassiopeiæ*, "the camel's hump," or "the hand."
(kaf) It is white in color, and culminates Nov. 11th.

CAS'-TOR, *α Geminorum*, "the horseman of the twins." Its color is bright white, and it culminates Feb. 23d. Situated in the head of Castor. The Century Dictionary gives the color as greenish.

CHELEB, *β Ophiuchi*, also CEB'ELRÁI from kelb, the shepherd's dog.
Situated in the head of the Serpent. It is a yellow star, and culminates Aug. 30th

CHORT, *θ Leonis*.
(chôrt) Situated in the hind quarters of the Lion. It culminates April 24th. The Century Dictionary has *θ Centauri* for this star.

COR CAROLI, α *Can. Ven.*, "the heart of Charles II."
(kôr kar'-ō-lī) It is flushed white in color, and culminates May 20th. A yellowish star according to the Century Dictionary.

CUJAM, ω *Herculis*. Word used by Horace for the club of Hercules.

CURSA, β Eridani, "the footstool of the central one," or
(ker'sa) "the chair or throne."
Situated about at the source of the river near Orion. Topaz yellow in color, and culminates January 13th. This star is also known as Dhalim (Tha'-lim) ("the ostrich").

DABIH, β *Capricorni*, "the lucky one of the slaughterers,"
(dä'-be) or "the slayer's lucky star."
Situated in the head of the Sea-Goat. It is an orange-colored star, and culminates Sept. 10th.

DĒ'-NEB, or ARIDED (ar'-i-ded) α *Cygni*, "the hen's tail," "the hindmost."
Situated in the tail of the Swan, and at the top of the Cross. Brilliant white in color. It is approaching the earth at the rate of two miles per second. It culminates Sept. 16th.

DENEB AL OKAB, ε and ζ *Aquilæ*, "the eagle's tail."
(den'-eb al ō-kâb)

DENEB ALGEDI, δ *Capricorni*, "the tail of the goat."
(den'-eb al'-jē-dē) Situated in the tail of the Sea-Goat.

DENEB AL SHEMALI, ι *Ceti*.
(den'-eb al she-mā'-le) A bright yellow star situated at the tip of the northern fluke of the monster's tail.

DENEB KAITOS, β *Ceti*, "the tail of the whale."
(den'-eb kī'-tos) Situated in the tail of the Whale. It is a yellow star, and culminates Nov. 21st. This star sometimes called Diphda.

DE-NEB'-O-LA, *β Leonis*, "the lion's tail."
It is a blue star which is approaching the earth at the rate of twelve miles per second. It culminates May 3d. This star also called Dafirah, and Serpha.

DSCHUBBA, *δ* Scorpii, "the front of the forehead."
In the head of the Scorpion. It culminates July 4th.

DSIBAN, *ψ Draconis*.
Pearly white in color.

DUB'-HE, *α Ursæ Majoris*, "a bear."
(dōb'-he) The northern pointer star. It is a yellow star, and is approaching the earth at the rate of twelve miles per second. It culminates April 21st. The Arabs called the four stars in the Dipper the "bier."

EL NATH *β Tauri*, the one who butts. This star is receding at the rate of five miles a second.

ELTANIN, or ETANIN (et'-ā-nin), *γ Draconis*, "the dragon," "the dragon's head."
It is orange in color and culminates Aug. 4th.
Rasaben is another name for this star.

E'-NIF, or en'-if, *ε Pegasi*, "the nose."
Situated in the nose of Pegasus. It is a yellow star, which is receding from the earth at the rate of five miles per second, and culminates Oct. 4th.
This star was also called fum-al-far-as, "the mouth of the horse."

ER RAI, *γ Cephei*, "the shepherd."
(er rā'-ē) Situated in the left knee of Cepheus. It is yellow in color and culminates Nov. 10th.

FOMALHAUT (fō'-mal-ō) (disputed pronunciation), *α Piscis Austri*, "the fish's mouth."
Situated in the head of the Southern Fish. It is reddish in color, and culminates Oct. 25th.
This star was also known as the first frog, the second frog being *β* Ceti.

FURUD, or PHURUD (fu-rōd) ζ *Canis Majoris*, "the bright single one." It is light orange in color.
Situated in the left hind paw of the Greater Dog.

GEM'-MA, α *Coronæ Borealis*, "a bud."
The brightest star in the Northern Crown. It is brilliant white in color, and is receding from the earth at the rate of twenty miles per second. It culminates June 28th. This star is also known as Alphecca and Alfeta.

GIANSAR λ *Draconis*, "the twins," "the poison place."
Situated in the tip of the Dragon's tail. An orange-colored star. It culminates April 28th.

GIEDI, α *Capricorni*, also called Algied'-i, the goat.
Situated in the head of the Sea-Goat. It is a yellow star, and culminates Sept. 9th.

GIENAH, γ *Corvi*, "the right wing of the raven."
Situated in the Crow's wing. It culminates May 10th.

GIENAH, ε *Cygni*, "the wing."
Situated in the Swan's wing. It is a yellow star, and culminates Sept. 17th.

GOMEISA, GOMELZA, β *Canis Minoris*, "Watery-eyed,
(gō-mī'-zä) weeping." A white star.
Situated in the neck of the Lesser Dog.

GRAFFIAS, β *Scorpii*, derivation unknown: the name may mean "the crab." This star was also called Ak'rab, the Scorpion. It is a pale white star, and culminates July 5th. Situated in the head of the Scorpion.

GRUMIUM, ξ *Draconis*, "the dragon's under jaw."
(grō'-mi-um) A yellow star.

HAM'-AL, α *Arietis*, "the head of the sheep."
or Situated in the forehead of the Ram. It is
(ha-mäl') yellow in color, and is approaching the earth at the rate of nine miles per second. It culminates Dec. 11th.

HOMAM, ζ *Pegasi*, "the lucky star of the hero, or the
(ho-mam′) whisperer."
Situated in the neck of Pegasus. Light yellow in color. It culminates Oct. 22d. The Century Dictionary gives this star name to η *Pegasi*.

HYADUM I, γ *Tauri*.
Situated in the Hyades, the nose of the Bull. A yellow star.

IZAR, MIRACH, or MIZAR, ϵ *Boötis*, "the girdle."
(ē-zär) Pale orange in color. It is approaching the earth at the rate of ten miles per second, and culminates June 16th. A beautiful colored double star.

JABBAH, ν *Scorpii*, "crown of the forehead."
(jab′-bä) A triple star.

KAUS AUSTRALIS, ϵ *Sagittarii*, "the southern part of the
(kâs) bow."
An orange-colored star. It culminates Aug. 8th.

KAUS BOREALIS, λ *Sagittarii*, "the northern part of the
(kâs) bow." Orange color.

KITALPHA, α *Equulei*, the Arab name for the asterism. In the head of the Little Horse. It culminates Sept. 24th.

KO′-CHAB, β *Ursæ Minoris*, "the star of the North."
(kō-käb′) Situated in the right shoulder of the Little Bear. One of the two Guardians of the Pole. It is reddish in color, and is receding from the earth at the rate of eight miles per second. It culminates June 19th.

KORNEPHOROS, β *Herculis*, the Arab name for the constellation.
Situated in the right armpit of Hercules. Pale yellow in color. It is approaching the earth at the rate of twenty-two miles per second. It culminates July 12th.

LESUTH, *ν Scorpii*, "the sting."
Situated in the tip of the Scorpion's tail. It culminates July 27th.

MAKFAK, *θ Cassiopeia*, "the elbow."
(mar'-fak) Situated in the left elbow of Cassiopeia. This star name is also given to *μ* Cassiopeiæ.

MARFIC, *λ Ophiuchi*, "the elbow."
(mar'-fik) Situated in the left elbow of the Serpent Bearer. Yellowish white in color.

MARFIK, or MARSIC, *κ Herculis*, "the elbow."
(mär'-fik) Situated in the right elbow of Hercules. Light yellow in color.

MAR'-KAB, *α Pegasi*. Arab word for "saddle." Century
(mar'-kab) Dictionary gives "a wagon" or "chariot." Situated in the base of the Horse's neck. It is a white star which is receding from the earth at the rate of three quarters of a mile a second. It culminates Nov. 3d.

MARKEB, *κ Argus*.
Situated in the stern of the Ship. It culminates Mar. 25th.

MARSYM, *λ Herculis*, "the wrist."
Situated in the left wrist of Hercules. Deep yellow in color.

MATAR or SAD (Sâd), "a lucky star," or more fully, Sad-Mator. *η Pegasi*, "the fortunate rain."
Situated in the left foreleg of Pegasus.

MEBUSTA, MEBSUTA (Meb-sō'-ta) or MEBOULA, *ε Geminorum*, "the outstretched."
A brilliant white star situated in the right knee of Castor.

MEDIA, or KAUS MEDIA, *δ Sagittarii*, "middle (of the) bow."
Orange yellow in color. It culminates Aug. 8th.

ME-GRES, or (Mē′-grez), δ *Ursæ Majoris*, "the root of the bear's tail."
It is a pale yellow star, and culminates May 10th. This star is the faintest of the seven which form the Dipper.

MEISSA, λ *Orionis*.
Situated in the face of the Giant Hunter. Pale white in color.

MEKBUDA, ζ *Geminorum*, "the contracted (arm)."
(mek-bū′-dä) Situated in the left knee of Pollux. Pale topaz in color.

MENKALINAN, β *Aurigæ*, "the shoulder of the rein-holder or driver."
(men-ka-lē-nan′ or men-kal′-i-nan) Situated in the right arm of the Charioteer. A lucid yellow star which is receding from the earth at the rate of seventeen miles per second. It culminates Jan. 29th. This star was one of the first discovered and most remarkable "spectroscopic binaries."

MENKAR, α *Ceti*, "the nose, or snout."
(men′-kär) Situated in the nose of Cetus. Bright orange in color. It culminates Dec. 21st. Sometimes written Menkab.

MENKIB, ξ *Persei*, "the shoulder."
Situated in the calf of the right leg of Perseus.

MERAK, β *Ursæ Majoris*, "the loin of the bear."
(mē′-rak) A greenish white star which is approaching the earth at the rate of eighteen miles per second. It culminates Apr. 20th. The southern of the two "pointers."

MESARTIM, γ *Arietis*, the Hebrew word for "minister."
(mē-sär′-tim) Situated in the Ram's left horn. Bright white in color.

MINTAKA, δ *Orionis*, "the belt (of the giant)."
(min′-ta-kä) One of the three stars in Orion's belt. A brilliant white star with very little motion. It culminates Jan. 24th.

MĪ′-RA, o *Ceti*.
(mī′-ra or mē′-ra) Situated in the neck of Cetus. A famous variable, flushed yellow in color. It culminates Dec. 15th.

MĪ′RACH, or MIRAK, β *Andromedæ*, "the girdle," or "the loins."
(mī′-rak or mē′-rak) A yellow star culminating Nov. 28th.

MĪZAR′, ζ *Ursæ Majoris*, "a girdle or apron."
(mī-zār′ or mē′-zār) Situated in the tail of the Great Bear. Brilliant white in color. It is approaching the earth at the rate of nineteen miles per second. It culminates May 28th.

MULIPHEN, γ *Canis Majoris*.
Situated in the neck of the Greater Dog. It culminates Feb. 26th.

MUPHRID, η *Boötis*, "the solitary star of the lancer."
(mū′-frid) Situated in the calf of the left leg of the Herdsman. Pale yellow in color. It culminates June 4th.

MURZIM or MIRZAM (mer-zäm′), β *Canis Majoris*, "the announcer" or "the roarer."
Situated in the Greater Dog's left fore paw. A white star culminating Feb. 5th.

MUSCIDA, o *Ursæ Majoris*, "the muzzle."
Situated in the nose of the Great Bear.

NEKKAR, or NAKKAR (nak′-kär), β *Boötis*, "the herdsman," the Arab name for the whole constellation.
Situated in the head of Boötes. A golden yellow star which culminates June 20th.

NAOS, *ζ Argus*, "the ship."
(nā′-os) Situated in the stern of the Ship. It culminates Mar. 3d.

NASHIRA, *γ Capricorni*, "the fortunate one, or the bringer of good tidings."
Situated in the tail of the Sea-Goat. It culminates Oct. 3d.

NIHAL, *β Leporis*.
Situated in the right foot of the Hare.
Deep yellow in color. It culminates Jan. 23d.

NODUS SECUNDUS, *δ Draconis*, "the second of the four knots or convolutions."
Deep yellow in color. It culminates Aug. 24th.

NUNKI, *σ Sagittarii*, "the star of the proclamation of the sea," or SADIRA (sad′-ē-ra), "the ostrich returning from the water."
Situated in the upper part of the Archer's left arm. It culminates Aug. 17th.

PHAD, PHEC′-DA, or PHAED (fā′-ed), *γ Ursæ Majoris*, "the thigh" (of the bear).
Topaz yellow in color. It is approaching the earth at the rate of sixteen miles per second. It culminates May 4th.

PHAET or PHACT, *α Columbæ*.
Situated in the heart of the Dove. It culminates Jan. 26th.

PHERKAD (fer′-kad), *γ Ursæ Minoris*, "the calf."
Situated in the right fore leg of the Little Bear.

PO-LA′-RIS, *α Ursæ Minoris*, "the pole star."
Situated in the tip of the Little Bear's tail. Topaz yellow in color. It is receding from the earth at the rate of sixteen miles per second.

POL'-LUX, β *Geminorum*, Ovid's "Pugil," the pugilist of the two brothers.

Situated in the head of Pollux. An orange-colored star which is receding from the earth at the rate of two miles per second. It culminates Feb. 26th. The Century Dictionary gives the color of Pollux as very yellow.

PORRIMA, γ *Virginis*, Latin name for "a goddess of
(por'-i-mä) prophecy." Situated in the Virgin's left arm. It culminates May 17th.

PRO'-CY-ON, α *Canis Minoris*, "the foremost dog."

A yellowish-white star. It is approaching the earth at the rate of two miles per second. It culminates Feb. 24th. In the right side of the Lesser Dog.

Dr. Elkin gives its distance as 12.3 light years, and its proper motion as 13.9 miles per second.

PROPUS, η *Geminorum*, "the forward foot."
(prō'-pus) Situated in the northern foot of Castor.

RASALAS, μ *Leonis*, "the lion's head toward the south."
(ras'-a-las) Situated in the Sickle, close to the Lion's right eye. An orange-colored star. It culminates Apr. 1st. Alshemali and Borealis are other names for this star.

RAS ALGETHI, α *Herculis*, "the kneeler's head."
(rās al-ge'-thi) Orange red in color. It culminates July 23d.

RAS'-AL-HĀG'-UE, α *Ophiuchi*, "the head of the serpent charmer."

A sapphire-hued star. It is receding from the earth at twelve miles per second. It culminates July 28th.

RASTABAN, β or γ *Draconis*, "the dragon's head," or "the
(rās-ta-bān') head of the basilisk."

A yellow star culminating Aug. 3d. This star also called Alwaid (al-wīd'), "the sucking camel-colts." The three stars near it are included in this appellation.

REG′-U-LUS, *α Leonis*, diminutive of the earlier Rex.
Situated in the handle of the Sickle, and the right fore paw of the Lion. It is flushed white in color, and is receding from the earth at the rate of three miles per second. It culminates April 6th. According to Dr. Elkin it is 35.1 light years distant, and has a proper motion of 10 miles per second.

RIGEL, *β Orionis*, "the [left] leg of the Jabbah, or giant."
(ri′-jel) A bluish-white star, which is receding from the earth at the rate of fourteen miles per second. It culminates Jan. 20th. This star is sometimes called Algebar (al′-je-bār).

ROTANEV, *β Delphini*, from Venator, assistant to Piazzi,
(rot′-a-nev) his name reversed.
It culminates Sept. 15th.

RUCHBA, *ω Cygni*, "the hen's knee."
A pale red star.

RUCHBAH, or RUCBAH, *δ Cassiopeiæ*, "the knee."
Situated in the left knee of Cassiopeia. It culminates Dec. 2d.

RUKBAT, *α Sagittarii*, "the archer's knee."
Situated in the left fore foot of the Archer. It culminates Aug. 24th.

SABIK, *η Ophiuchi*.
A pale yellow star in the left leg of the Serpent Bearer. It culminates Aug. 21st.

SADACHBIA, *γ Aquarii*, "the luck star of hidden things."
(sād-ak-bē′-yā) Greenish in cloor and situated in the water jar of Aquarius. It culminates Oct. 16th.

SAD AL BARI, *λ* and *μ Pegasi*, "the good luck of the excelling one."
Situated close to the fore legs of Pegasus.

SADAL MELIK or RUCBAH, α *Aquarii*, "the lucky star of
(säd-al-mel′-ik) the king."
A red star situated in the right shoulder of Aquarius. It culminates Oct. 9th.

SADALSUND, or SADALSUUD (säd-al-sō-ōd), β *Aquarii*, "the luckiest of the lucky."
Pale yellow in color. Situated in the left shoulder of Aquarius. It culminates Sept. 29th.

SADATONI, ζ *Aurigæ*.
(sad-a-tō′-ni) One of the three stars known as "the kids." Orange color.

SADR or SADIR (sä′-dēr), γ *Cygni*, "the hen's breast."
(sadr) This star is approaching the earth at the rate of four miles per second. It culminates Sept. 11th.

SAIPH, κ *Orionis*, "the sword of the giant."
(sā-if′) Situated in Orion's right knee. It culminates Jan. 27th.

SARGAS, θ *Scorpii*.
A red star situated in the tail of the Scorpion. It culminates July 27th.

SCHEAT or MENKIB, β *Pegasi*, "the upper part of the arm."
(she′-at) Situated in the left fore leg of Pegasus. It is deep yellow in color, and is receding from the earth at the rate of four miles per second. It culminates Oct. 25th.

SCHEMALI, *see* Deneb al schemali, ι *Ceti*.

SEGINUS, γ *Boötis*, from Ceginus of the constellation,
(se-jī′-nus) possibly.
Situated in the left shoulder of Boötes. It culminates June 13th.

SHAULA, λ *Scorpii*, "the sting."
(shâ′-lä) In the tip of the Scorpion's tail.

SHEDAR, SCHEDIR, or SHEDIR, α *Cassiopeiæ*, "the breast," or from El Seder, "the sedar tree," a name given to this constellation by Ulugh Beigh.
Pale rose in color. It culminates Nov. 18th.

SHELIAK, or SHELYAK (shel′-yak), "a tortoise," β *Lyræ*, Arabian name for the constellation.
A very white star culminating Aug. 17th.

SHERATAN, β *Arietis*, "a sign," or "the two signs."
(sher-a-tan′) Situated in the Ram's horn. A pearly white star culminating Dec. 7th.

SIR′-I-US, α *Canis Majoris*, "the sparkling star or scorcher." Situated in the mouth of the Great Dog. Brilliant white in color. The brightest of the fixed stars. It culminates Feb. 11th.

SITULA, κ *Aquarii*, "the water jar or bucket."
(sit′-ū-lä) Situated in the rim of the Water Jar.

SKAT, or SCHEAT, δ *Aquarii*, "a wish," or possibly it means a "shin bone."
Situated in the right leg of Aquarius.

SPĪ′CA, α *Virginis*, "the ear of wheat or corn" (held in the Virgin's left hand).
A brilliant flushed white star, which is receding from the earth at the rate of one mile a second. It culminates May 28th.

SUALOCIN, or SVALOCIN (sval′-ō-sin), Nicolaus reversed, α *Delphini*.
A pale yellow star culminating Sept. 15th.

SULAFAT, or SULAPHAT (sö′-lä-fät), "the tortoise," γ *Lyræ*.
Arabian title for the whole constellation.
It is bright yellow in color, and culminates Aug. 19th.

SYRMA, ι *Virginis;* this name used by Ptolemy to designate this star in the train of the Virgin's robe.

TALITA, κ or ι *Ursæ Majoris*, "the third vertebra."
(tä′-lē-tä) Situated in the right fore paw of the Great Bear. Topaz yellow in color.

TANIA BOREALIS, λ *Ursæ Majoris*.

TANIA AUSTRALIS, μ *Ursæ Majoris*, a red star.
These stars are situated in the right hind foot of the Great Bear. The former star culminates Apr. 8th.

TARAZED, γ *Aquilæ*, "the soaring falcon," part of the
(tar′-a-zed) Persian title for the constellation.
Situated in the body of the Eagle. A pale orange star, culminating Aug. 31st.

TEGMENI, ζ *Cancri*, "in the covering."
A yellow-colored star.

TE′-JAT, μ *Geminorum*.

THU′-BAN, α *Draconis*, "the dragon," the Arab title for
or the constellation.
(thö-bän′) Situated in one of the Dragon's coils. It is pale yellow in color, and culminates June 7th.

UNUK AL HAY, α *Serpentis*, "the neck of the snake."
or A pale yellow star which is receding from
UNUKALHAI the earth at the rate of fourteen miles a
(ū′-nuk-al-hä′-i) second. It culminates July 28th.

VË′GA, or WEGA, α *Lyræ*, "falling," *i. e.*, the falling bird, "the harp star."
A beautiful pale star sapphire in color. It is approaching the earth at the rate of nine miles a second. It culminates Aug. 12th.

VINDEMIATRIX, ε *Virginis*, "the vintager or grape gatherer."
Situated in the Virgin's right arm. A bright yellow star culminating May 22d.

WASAT, δ *Geminorum*, "the middle."
(wä′-sat) Situated in the body of Pollux. Pale white in color. It culminates Feb. 19th.

WESEN, δ *Canis Majoris*, "the weight."
A light yellow star in the right side of the Great Dog. It culminates Feb. 17th.

YED PRIOR, δ *Ophiuchi*, "the hand," "the star behind or following."
(yed) Deep yellow in color. It culminates July 7th. It is in the left hand of the Serpent Bearer.

YED POSTERIOR, ε *Ophiuchi*, "the hand."
A red star culminating July 8th.

YILDUN, δ *Ursæ Minoris*.
Situated in the tail of the Little Bear. A greenish-hued star culminating Aug. 12th.

ZANIAH, η *Virginis*.
Situated in the Virgin's left shoulder.

ZAURAK, γ *Eridani*, "the bright star of the boat."
(zâ′-rak) A yellow star.

ZAVIJAVA, β *Virginis*, "angle or corner," "the retreat or kennel of the barking dog."
(zav-i-ja′-va) Situated on the Virgin's left wing. A pale yellow star culminating May 3d.

ZOSMA, δ *Leonis*, "a girdle."
(zŏs′-ma) Situated at the root of the Lion's tail. A pale yellow star which is approaching the earth at the rate of nine miles a second. It culminates Apr. 24th. This star is also called Duhr, and sometimes Zubra.

ZUBENAKRAVI, γ *Scorpii*, "the claw of the Scorpion."
(zŏ-ben-ak′-ra-vi or bi) A red star.

ZUBEN ELGENUBI (zŏ-ben-el-jen-ū′-bi), α *Libræ*, "the southern claw" (of the Scorpion).
A pale yellow star culminating June 17th. This star is also called Kiffa Australis.

ZUBEN ESCHAMALI, *β Libræ*, "the northern claw." (zō-ben-es-she-ma′-li)

A pale emerald color, a very unusual color for a star. It is approaching the earth at the rate of six miles a second and culminates June 23d. This star is also known as "Kiffa Borealis."

In the compilation of the foregoing list, the author has been greatly assisted by Allen's "Star Names and their Meanings."

APPENDIX

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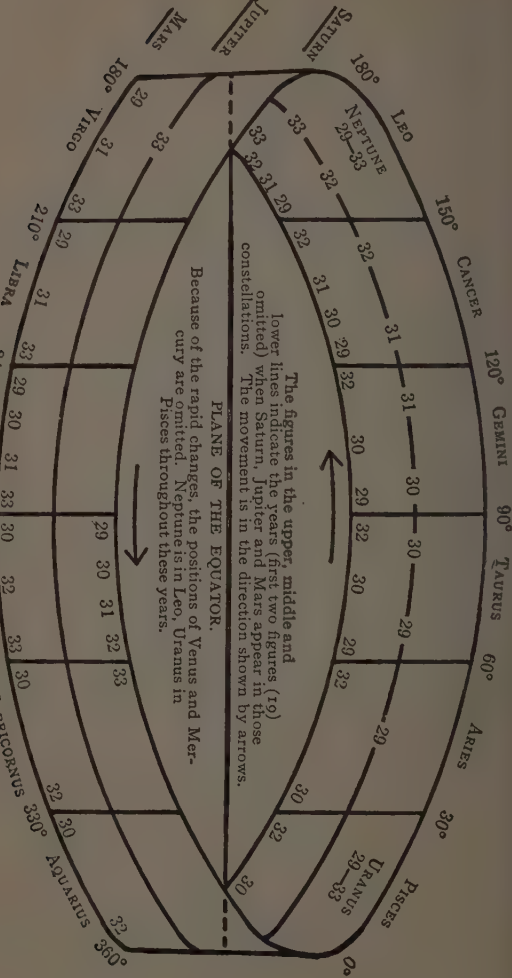
ELEMENTS OF THE SOLAR SYSTEM

	Symbol	Mean Distance from Sun in Miles	Diameter in Miles	Mass ⊗ = 1	Volume ⊗ = 1	Magnitude*	Year	Day	Moons
Sun	☉		864,100	331,950	1,300,000	−26.7			
Moon	☾	238,857 from earth	2,160	$\frac{1}{81.5}$	0.02	−12.5			
Mercury	☿	36,000,000	3,125	0.04	0.06	0.16†	88 days	88 days	
Venus	♀	67,200,000	7,750	0.81	0.92	−4.07†	224.7 days	?	
Earth	⊗	92,870,000	7,963	1			365 days	23 h., 56 m.	1
Mars	♂	141,500,000	4,231	0.108	0.15	−1.85	687 days	24 h., 37 m.	2
Jupiter	♃	483,000,000	87,225	316.9	1312	−2.23	11 yrs. 10 mo. 17 days	9 h., 55 m.	9
Saturn	♄	886,000,000	71,937	94.9	734	+0.89 to −0.18	29.5 yrs.	10 h., 14 m.	10
Uranus	♅	1,782,000,000	31,875	14.6	64	5.74	84 yrs.	10.7 hrs.	4
Neptune	♆	2,792,000,000	31,250	17.	60	7.65	164.7 yrs.		1

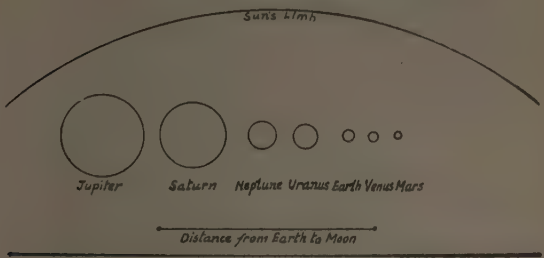
* At Opposition. † At Elongation.

The Moon revolves on its axis and about the Earth in a period of 27 days, 7 hours, 43 minutes.
The Sun revolves on its axis once in 25 days, 7 hours, 48 minutes. It is moving toward Lyra at the rate of 12 miles a second.
The Earth moves in its orbit around the Sun at a mean rate of 18.5 miles a second.



The Planets on the Ecliptic.

COMPARATIVE SIZES OF THE PLANETS



ELEMENTS OF THE MOONS OF JUPITER

Name or Number	Mean Dist. from Jup.	Periods of Revol.' days	hrs.	min.	sec.	Diameter in miles
V	112,500	0	11	57	27	?(very small)
I (Io)	261,800	1	18	27	36	2450
II (Europa)	416,600	3	13	17	54	2050
III (Ganymede)	664,000	7	3	59	35	3560
IV (Calypso)	1,168,000	16	18	5	7	3350
VI	7,100,000	8½ months				?(very small)
VII	7,300,000	9		"		? " "
VIII	14,600,000	24½		"		? " "
IX	15,000,000	24½		"		? " "
VII	7,300,000	9		"		? " "
VIII	14,600,000	24½		"		? " "
IX	15,000,000	24½		"		? " "

Professor Barnard has seen white polar caps on satellites III and IV. "They are exactly like those of Mars."

Satellites VIII and IX are extremely small, not more than a few miles in diameter. Their orbits are so eccentric that their greatest distances from Jupiter are nearly twice their least distances. The revolution of each around the planet is in a retrograde direction.

ELEMENTS OF THE MOONS OF SATURN

	Mean Dist. fr. Saturn	Periods of Revol.			Diameters in miles (Approximately)
		days	hrs.	min.	
I. Mimas	117,000		22	36	600
II. Enceladus	157,000	1	8	54	800
III. Tethys	186,000	1	21	18	1,100(?)
IV. Dione	238,000	2	17	42	1,200(?)
V. Rhea	332,000	4	12	30	1,000(?)
VI. Titan	771,000	15	22	41	2,625
X. Themis	906,000	20	20(?)	0	30(?)
VII. Hyperion	943,000	21	7	36	500
VIII. Japetus	2,225,000	79	7	56	1,125(?)
IX. Phœbe	7,300,000	580	2	54	40(?)

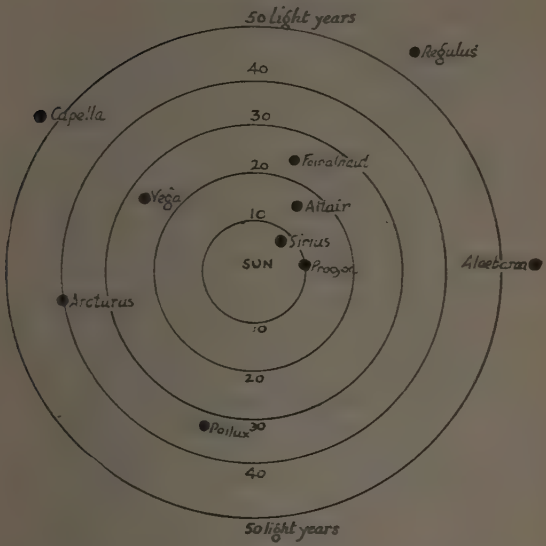
The revolution of Phoebe, satellite IX is retrograde.

ELEMENTS OF THE MOONS OF URANUS

	Dist. from Planet	Periods of Revol.			Diameter (*Est. only*)
		day	hour	min.	
Ariel	120,000	2	12	30	600
Umbriel	167,000	4	3	30	500
Titania	293,000	8	16	50	1200
Oberon	365,000	13	11	6	1000

These four satellites revolve in a plane nearly perpendicular to the ecliptic. It seems probable that "the equatorial plane of Uranus coincides with the orbit plane of its satellites"; that is that the planet seems to "*roll* on its side."

The Nearest Ten Bright Stars



Sixty trillion miles is the distance between the concentric rings.

THE BRIGHTEST STARS VISIBLE IN LATITUDE 40° N.*

STAR	MAGNITUDE
The Sun	—25.4
Sirius	—1.58
Vega	0.14

* With the exception of the estimate of the sun's magnitude the list is taken from the Harvard Observatory Catalogue.

Other results for the stellar magnitude of the sun are as follows:

Brightest Stars—*Continued*

Capella	0.21
Arcturus	0.24
Rigel	0.34
Procyon	0.48
Altair	0.89
Betelgeuze	0.9
Aldebaran	1.06
Pollux	1.21
Spica	1.21
Antares	1.22
Fomalhaut	1.29
Deneb	1.33
Regulus	1.34
Castor	1.58
ϵ Canis Majoris	1.63
ϵ Ursæ Majoris	1.68
Bellatrix	1.70
λ Scorpii	1.71
ϵ Orionis	1.75
β Tauri	1.78
α Persei	1.90
ζ Orionis	1.91
η Ursæ Majoris	1.91
γ Geminorum	1.93

Wollaston: −26.6
Bond: −25.8
Zöllner: −26.6

The sun gives us: 10,000,000,000 times the light of Sirius.

The total light of all the stars in the heavens is equal to that of 1092 stars of visual magnitude 1.0.

THE NEAREST STARS*

STAR NAME	MAGNITUDE	DISTANCE IN LIGHT YEARS
"Proxima"	10.5	4.3
α Centauri	0.3	4.3
Barnard's Star	9.7	6.1
Lalande 21185	7.4	8.1
Sirius	0.38	8.6
Anonymous	12.0	9.6
Kapteyn's Star	9.2	10.3
τ Ceti	3.6	10.3
Procyon	0.5	10.4
ε Eridani	3.8	10.5
61 Cygni	5.6	10.9
Lacaille 9352	7.4	11.2
Σ 2398	8.7	11.4
Groombridge 34	8.1	11.6
ε Inde	4.7	11.6
Krüger 60	9.6	12.7
van Maanen's Star	12.3	12.8
Cordoba 29191	6.6	12.9

The distance that separates us from Proxima Centauri, the nearest star, is better realized if we adopt Professor Young's comparison. If the distance from the Earth to the Sun were 215 feet, the distance from the Earth to Proxima Centauri would be 8000 miles.

The mean distance of the stars of the first magnitude is 36.5 light years, second magnitude stars 58 light years, and third magnitude stars 92 light years, from estimates made at the Yale University Observatory.

* From the Revision of Young's Manual of Astronomy by Professors Russell, Dugan, and Stewart.

NUMBER OF THE STARS*

First Magnitude	20	
Second "	65	
Third "	200	
Fourth "	500	
Fifth "	1,400	
Sixth "	5,000	
Seventh "	20,000	
Eighth "	68,000	
Ninth "	240,000	
Tenth "	720,000	1,055,185

The lucid, or naked-eye, stars comprise the first six magnitudes.

There are in the heavens between six and seven thousand stars visible to the naked eye. Only twenty-five hundred of these are visible at any one time. A good field glass reveals over fifty thousand stars and Argelander observed 324,000 stars with a 2.5-inch telescope. The Yerkes 40-inch refractor, the largest refractor in the world, probably reveals one hundred million stars, while fully a billion stars are within the range of the great 100-inch reflector at the Mt. Wilson Observatory.

* From Todd's *Astronomy*.

FAMOUS VARIABLE STARS

STAR NAME	PERIOD IN DAYS	RANGE IN MAGNITUDE	REMARKS
o Ceti	331	1.7– 9.5	Mira
R Leonis	313	5.2–10.0	
β Persei	$2\frac{7}{8}$	2.3– 3.5	Algol
ζ Geminorum	$10\frac{1}{7}$	3.7– 4.5	
δ Libræ	$2\frac{1}{3}$	5.0– 6.2	
χ Sagittarii	7	4 – 6	
β Lyræ	12.9	3.4– 4.9	
α Herculis	90±	3.1– 3.9	Irregular
δ Cephei	$5\frac{1}{2}$	3.7– 4.6	

FAMOUS TEMPORARY STARS (NOVÆ)

DATE	APPEARING IN THE CONSTELLATION
134 B.C.	Scorpius
123 A.D.	Ophiuchus
386	Sagittarius
389	Aquila
393	Scorpius
1012	Aries
1203	Scorpius
1230	Ophiuchus
1572	Cassiopeia (Tycho's Star)
1604	Ophiuchus (Kepler's Star)
1670	Vulpecula
1848	Ophiuchus
1860	Scorpius
1866	Corona Borealis
1876	Cygnus
1885	Andromeda
1891–92	Auriga

RECENT TEMPORARY STARS (NOVÆ)

DATE	APPEARING IN THE CONSTELLATION
1901	Perseus
1903	Gemini
1905	Aquila
1910	Lacerta
1912	Gemini
1918	Aquila

THE FIRST SIXTEEN VARIABLE STARS DISCOVERED

STAR	PERIOD IN DAYS	DISCOVERER	DATE
o Ceti*	331.7	Fabricius	1596
β Persei	2.9	Montanari	1669
χ Cygni*	406.0	Kirch	1686
R Hydræ*	452.2	Maraldi	1704
R Leonis*	312.8	Koch	1782
η Aquilæ	7.2	Pigott	1784
β Lyræ	12.9	Goodricke	1784
δ Cephei	5.4	Goodricke	1784
α Herculis	Irreg.	W. Herschel	1795
R Coronæ	Irreg.	Pigott	1795
R Scuti	Irreg.	Pigott	1795
R Virginis*	145.5	Harding	1809
R Aquarii*	387.2	Harding	1811
R Serpentis*	357.2	Harding	1826
S Serpentis*	368.5	Harding	1828
R Cancri*	362	Schwerd	1829

Compiled by Dr. Paul W. Merrill

Stars marked with an asterisk are typical long period Variables.

RIGHT ASCENSIONS AND DECLINATIONS OF SOME BRIGHT STARS

		R.A.		DEC.
		Hours	Minutes	
ALPHERATZ	(α Andromedæ)	0	2.4	N. 28°29′
ALGENIB	(α Perseus)	III	17.2	N. 49°30′
ALDEBARAN	(α Tauri)	IV	31.3	N. 16°21′
RIGEL	(β Orionis)	V	10.7	S. 8°17′
CAPELLA	(α Aurigæ)	V	10.7	N. 45°56′
BETELGEUZE	(α Orionis)	V	50.8	N. 7°24′
SIRIUS	(α Canis Majoris)	VI	41.6	S. 16°35′
CASTOR	(α Gemini)	VII	29.5	N. 32° 4′
PROCYON	(α Canis Minoris)	VII	35.1	N. 5°27′
POLLUX	(β Gemini)	VII	40.4	N. 20°13′
REGULUS	(α Leonis)	X	4.1	N. 12°21′
SPICA	(α Virginis)	XIII	19.9	S. 10°38′
ARCTURUS	(α Boötes)	XIV	12.1	N. 19°38′
ANTARES	(α Scorpii)	XVI	24.5	S. 26°16′
VEGA	(α Lyræ)	XVIII	34.2	N. 38°42′
ALTAIR	(α Aquilæ)	XIX	46.9	N. 8°39′
DENEB	(α Cygni)	XX	38.8	N. 32° 1′

The Celestial Equator runs through the belt stars of Orion, 5 degrees below Procyon, some 10 degrees below Regulus and Altair and 10 degrees above Spica.

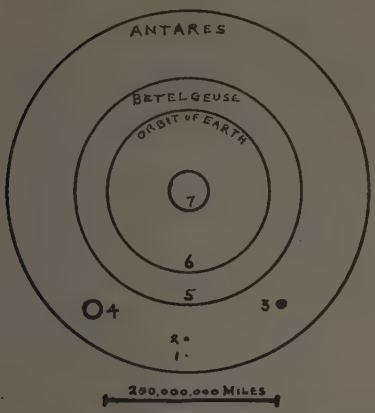
TABLE OF PARALLAXES, PROPER MOTION, AND RADIAL VELOCITY OF BRIGHTEST STARS

	Magnitude	*Distance in light years*	*Cross motion miles a second*	*Approaching — Receding + miles a second*	*Luminosity Sun = 1*
Sirius	−1.58	8.8	11	−8	26
Procyon	0.48	10.5	12	−2	5
Altair	0.89	16	9	−20	9
Fomalhaut	1.29	24	8	+4	13
Deneb	1.23	32	24	+1	11
Vega	0.14	26	8	−9	50
Arcturus	0.24	41	84	−3	100
Aldebaran	1.06	57	11	+34	90
Capella	0.21	47	19	+19	150
Pollux	1.21	32	18	+2	28
Polaris	2.12	470:	29	−15	2,500:
Regulus	1.34	56	10	+3	70
Betelgeuze	0.92	190	6	+13	1,200
Antares	1.22	360	11	−2	3,400:
Castor	1.58	43	8	+2	11
Rigel	0.34	540:	2	+14	18,000:
Deneb	1.33	650:	12	−2	10,000:
Spica	1.21	230	17	+1	1,500
Mira	1.7–9.6	220	76	+64	790–0.55
α Coronæ	2.31	61	14	+0	38
Andromeda Nebula		870,000:			
Orion Nebula		600:		+600	
Præsepe		450:			
Coma Berenices		300:			
Pleiades		320			
Hyades		140			

The (:) indicates that the value is uncertain.

The author gratefully acknowledges his indebtedness to Professor S. A. Mitchell for valued assistance in the preparation of the above table.

GIANT AND DWARF STARS



1. The Sun. 2. Vega. 3. Capella. 4. Arcturus. 5. Betelgeuze 6. Orbit of Earth. 7. Aldebaran. Compare Sun and Vega with lower diagram.

1. Proxima Centauri. 2. 61 Cygni. 3. Companion to Sirius. 4. Jupiter.

This scale is 200 times the scale of the upper diagram.

STARS RECEDING FROM THE EARTH

STAR NAME	SPEED IN MILES PER SECOND
Regulus	3
Aldebaran	34
Rigel	14
Fomalhaut	4
Denebola	1
Betelgeuze	13
Capella	19
Pollux	2
Castor	2
Spica	1
Mira	64

STARS APPROACHING THE EARTH

STAR NAME	SPEED IN MILES PER SECOND
Altair	12
Polaris	15
Arcturus	3
Vega	9
Deneb	2
Sirius	8
Procyon	2
Antares	2

STARS OF LARGEST PROPER MOTION*

	MAG'	PROPER MOTION SEC. OF ARC A YEAR	RADIAL VELOCIT. Approaching — Receding	CROSS MOTION OR TANGENTIAL VELOCITY
			Miles per Second	
Barnard's star	9.6	10″.25	−73	56
Kapteyn's star	9.2	8 .76	+15	81
Groombridge 1830	6.4	7 .05	−60	206
Lacaille 9352	7.4	6 .90	+ 7	70
Cordoba 32416	8.3	6 .11	+16	82
61 Cygni	5.5 / 6.2	5 .20	+40	51

The Moon's apparent angular diameter (Equatorial) is 31′5″ (Mean).

THE RHYME OF THE ZODIAC

The Ram, the Bull, the heavenly Twins,
And next the Crab, the Lion shines,
The Virgin, and the Scales.
The Scorpion, Archer, and the Goat,
The Man who pours the Water out,
And Fish with glittering tails.

* From the Revision of Young's *Manual of Astronomy*, by Professors Russell, Dugan, and Stewart.

TABLE SHOWING THE STARS OF THE FIRST AND SECOND MAGNITUDE RISING IN THE EASTERN SKY AT NINE O'CLOCK P.M. ON THE DATES SPECIFIED.

DATE	NAME OF STAR	CONSTELLATION
January 1	Regulus, 1st	Leo
" 8	Alphard, 2d	Hydra
" 11	Cor Caroli	Canes Venatici
February 20	Arcturus, 1st	Boötes
March 1	Spica, 1st	Virgo
" 5	Gemma, 2d	Corona Borealis
April 1	Vega, 1st	Lyra
" 20	Ras Alhague, 2d	Ophiuchus
" 22	Deneb, 2d	Cygnus
May 9	Antares, ?	Scorpio
" 26	Altair, 1st	Aquila
June 5		Delphinus
July 17	Algenib, 2d	Perseus
August 6	Algol	Perseus
" 21	Capella, 1st	Auriga
" "	Hamal, 2d	Aries
" 27	Fomalhaut, 1st	Piscis Australis
September 13		The Pleiades in Taurus
October 2	Aldebaran, 1st	Taurus
" 26	Bellatrix, 2d	Orion
" 30	Castor, 1st	Gemini
" "	Betelgeuze, 1st	Orion
November 4	Pollux, 2d	Gemini
" "	Rigel, 1st	Orion
" 27	Procyon, 1st	Canis Minor
December 4	Sirius, 1st	Canis Major
" 8	Phaet, 2d	Columba
" 14		The Bee Hive in Cancer
" 16		The head of Hydra

PERIODIC COMETS

(Observed in at least one return since discovery)

Name	*Year of first discovery*	*Date of perihelion at last observed return*	*Period at last return, years*	*No. of returns observed since discovery*	*Due to return in*
Encke	1786	1924 Oct.	3.3	35	1928
Grigg-Skjellerup	1902	1927 May	5.0	2	1932
Tempel II	1873	1925 Aug.	5.2	6	1930
Neujmin	1916	1927 Jan.	5.4	2	1932
Tempel III—Swift	1869	1908 Oct.	5.7	3	1931
Pons-Winnecke	1819	1927 June	6.0	10	1933
D'Arrest	1851	1923 Sept.	6.6	7	1930
Giacobini-Zinner	1900	1926 Dec.	6.6	2	1933
Kopff	1906	1926 Jan.	6.6	2	1932
Finlay	1886	1926 Aug.	6.7	4	1933
Borrelly	1905	1925 Oct.	6.9	3	1932
Brooks	1889	1925 Nov.	6.9	4	1932
Holmes	1892	1906 Mar.	6.9	2	1928
Faye	1843	1925 Aug.	7.3	8	1932
Schaumasse	1911	1927 Oct.	8.0	2	1935
Wolf	1884	1925 Oct.	8.2	5	1933
Tuttle	1790	1926 Apr.	13.5	6	1939
Westphal-Delavan	1852	1913 Nov.	61.7	1	1975
Brorsen-Metcalf	1847	1919 Oct.	69.0	1	1988
Pons-Brooks	1812	1884 Jan.	71.4	1	1956
Olbers-Brooks	1815	1887 Oct.	72.5	1	1960
Halley	240 B.C.	1910 Apr.	76.0	28	1986
Three Lost Periodic Comets:					
Brorsen	1846	1879	5.5	4	
Tempel I	1867	1879	6.0	2	
Biela	1772	1852	6.7	5	

The author acknowledges his indebtedness and gratitude to Professor George Van Biesbroeck for the data contained in this table.

PERPETUAL STAR TIME-PIECE, COMPASS, AND CALENDAR

If you know the star-pictures, and memorize the following rhyme, you will ever have at hand for reference on clear nights, a reliable time-piece, compass, and calendar.

The numbers above the star names indicate consecutively the months of the year in which these respective objects rise about the first of each month in the eastern sky. In addition to first magnitude stars the rhyme refers to the head of Capricornus, the Sea-Goat, the Great Square of Pegasus, and Orion's Belt. All except Arcturus rise between 9 and 9:30 P.M. Arcturus rises at 10 P.M. February 1st.

1
First Regulus gleams on the view,
2 3 4
Arcturus, Spica, Vega, blue,
5 6
Antares, and Altair,
7 8 9
The Goat's head, Square, and Fomalhaut,
10 11
Aldebaran, the Belt, a-glow,
12
Then Sirius most fair.

Eight months of the year are identified by the position of the Big Dipper at 9 P.M. In April and May it is north of the zenith. During July and August it is west of north. In October and November it lies close to the northern horizon and in January and February it is east of north with the "Pointer Stars" highest.

GENITIVE CASE OF THE CONSTELLATIONS

Andromeda	Andromedæ	Hercules	Herculis
Aquarius	Aquarii	Hydra	Hydræ
Aquila	Aquilæ	Lacerta	Lacertæ
Aries	Arietis	Leo	Leonis
Auriga	Aurigæ	Lepus	Leporis
Boötes	Boötis	Libra	Libræ
Cancer	Cancri	Lyra	Lyræ
Canis Major	Canis Majoris	Monoceros	Monocerotis
Canis Minor	Canis Minoris	Ophiuchus	Ophiuchi
Capricornus	Capricorni	Orion	Orionis
Cassiopeia	Cassiopeiæ	Pegasus	Pegasi
Cepheus	Cephei	Perseus	Persei
Cetus	Ceti	Pisces	Piscium
Corona	Coronæ	Sagittarius	Sagittarii
Corvus	Corvi	Scorpius	Scorpii
Crater	Crateris	Taurus	Tauri
Cygnus	Cygni	Triangulum	Trianguli
Delphinus	Delphini	Ursa Major	Ursa Majoris
Draco	Draconis	Ursa Minor	Ursa Minoris
Eridanus	Eridani	Virgo	Virginis
Gemini	Geminorum	Vulpecula	Vulpeculæ

THE GREEK ALPHABET

α	Alpha	ν	Nu
β	Beta	ξ	Xi
γ	Gamma	ο	Omicron
δ	Delta	π	Pi
ε	Epsilon	ρ	Rho
ζ	Zeta	σ	Sigma
η	Eta	τ	Tau
θ	Theta	υ	Upsilon
ι	Iota	φ	Phi
κ	Kappa	χ	Chi
λ	Lambda	ψ	Psi
μ	Mu	ω	Omega

ASTRONOMICAL SYMBOLS USED IN ALMANACS

☿ =Mercury.
♀ =Venus.
⊕ =Earth.
♂ =Mars.
♃ =Jupiter.
♄ =Saturn.
♅ or ♢ =Uranus.
♆ =Neptune.

● =New Moon.
☽ =First Quarter.
○ =Full Moon.
☾ =Last Quarter.
☉ =Sun.
☌ =Conjunction; having the same Right Ascension. This does not necessarily mean at the same point on the celestial sphere, since the Declination of the two bodies may be different.
☍ Opposition; differing 180° in Right Ascension
□ =Quadrature; differing 90° in Right Ascension

Examples:

☌ ♃ ♀ =Jupiter and Venus in conjunction.
☍ ♂ ☉ =Mars in opposition.
☌ ♃ ☉ =Jupiter in conjunction with the Sun.
☌ ☿ ☉ Inf.=Mercury in inferior conjunction; between the Earth and the Sun.
☌ ☿ ☉ Sup.= Mercury in superior conjunction; on the other side of the Sun from the Earth.
☌ ♀ ☾ =Venus and Moon in conjunction.

(*For Signs of the Zodiac see page 376.*)

A BRIEF BIBLIOGRAPHY

FOR GENERAL READING

ARRHENIUS, S. A. *Destinies of the Stars.* Illus. 12mo. 1918. $2.00

Good reading, but not "up to the moment" in theory.

BALL, SIR ROBERT. *Story of the Heavens.* Illus. 8vo. 560 pages. 1897. $3.50

This remains one of the best comprehensive general books. It lacks, of course, the knowledge acquired in the past thirty years. The author's attitude is strictly conservative.

—— *Great Astronomers.* 12mo. $1.50

Good short biographies.

EDDINGTON, A. S. *Nature of the Physical World.* 8vo. 360 pages. 1928. $3.75

A BOOK among myriads! While, from a strictly astronomical standpoint it must be classed as collateral reading, no one interested in science can afford not to study it thoroughly. Its title describes it. It is written in Dr. Eddington's remarkably able and charming style.

—— *Stars and Atoms.* Illus. 8vo. 127 pages. 1928. $2.00

A fascinating book, presenting the recent advances in knowledge concerning the constitutions of the stars—their ages etc.—and how the knowledge is secured.

HALE, G. E. *Depths of the Universe.* Illus. 12mo. 1924. $1.50

—— *New Heavens.* Illus. 12mo. 1922. $1.50

Reprints of excellent magazine articles reporting the results of recent most interesting work at the Mt. Wilson observatory.

JEANS, J. H. *Astronomy and Cosmogony.* Illus. 4to. 418 pages. 1928. $10.00

This dignified work describes in full the author's views "on the present position of Cosmogony, the physical state of astronomical matter, the structure of the stars, the origin of their radiation, etc." Dr. Jeans "has tried to depict the present situation in the simplest language consistent with scientific accuracy, avoiding technicalities where possible, and otherwise explaining them." Much fairly complicated mathematics have, of necessity, been included. For the advanced reader a fine book.

—— *Eos, of the Wider Aspects of Cosmogony.* Illus. 16 mo. 88 pages. 1929. $1.

An epitome of the large book. All mathematics and much detail omitted.

LOWELL, PERCIVAL. *Evolution of Worlds.*
Mars as the Abode of Life.
Mars.
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"Their nature, possibilities and habit-ability by the light of the latest discoveries."

A fine book on the Solar System and its members. It does not present, however, the very recent measurements of the temperatures of the major planets, and the views on their surface conditions are not those held today.

SHAPLEY, HARLOW. *Starlight.* Illus. 16mo. 143 pages. 1926. $1.50

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TURNER, H. H. *Astronomical Discovery.* Illus. 8vo. 225 pages. 1904. $3.75

Well told stories of the important astronomical discoveries—Uranus, Neptune, the Asteroids, etc.

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FAUTH, PHILIP. *The Moon in Modern Astronomy.* Illus. 8vo. 160 pages. $2.00

A summary of twenty years selenographic work, and a study of recent problems.

Not only excellent special reading, but most useful to the observer. Contains many *detailed* charts, drawn by the author.

PROCTOR, M. *Romance of the Sun.* Illus. 12mo. 1927. $2.50

One of the most readable books devoted entirely to the Sun.

NASMYTH and CARPENTER. *The Moon, Considered as a Planet, a World, and a Satellite.* Illus. 12mo. 315 pages. $2.00

One of the most interesting books on the Moon. It devotes much space to the exposition in simple language of the authors' theories regarding the origin of the lunar surface markings.

MORE TECHNICAL BOOKS

ABBOT, C. G. *Fundamentals of Astronomy.* Illus. 2nd Ed. 1927. $3.00

A fine text-book.

FATH, E. A. *Elements of Astronomy.* Illus. 8vo. 325 pages. 2nd Ed. 1928. $3.00

A non-mathematical text-book. Exceptionally fine. Wonderfully illustrated. Worth far more than its price. Invaluable as a reference book, and most pleasant for general reading.

RUSSELL, DUGAN and STEWART. *Astronomy.* Illus. 12mo. 2 vols. 1928. $5.00

Possibly the most comprehensive text-book. Vol. I is devoted to the solar system, Vol. II to Astrophysics and Stellar Astronomy.

SERVISS, G. P. *Astronomy in a Nutshell.* Illus. 12mo. 260 pages. 1926. $1.75

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The names of the lunar surface features are also omitted and are given in the special **INDEX TO THE MOON.** beginning on page 518.

In setting this index different faces of type have been used as follows:

General references, such as "magnitude," thus: Magnitude.

Astronomers, thus: **Shapley.**

Mythological names, etc., thus: CALLISTO.

Star and Planet names, etc., thus: JUPITER.

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